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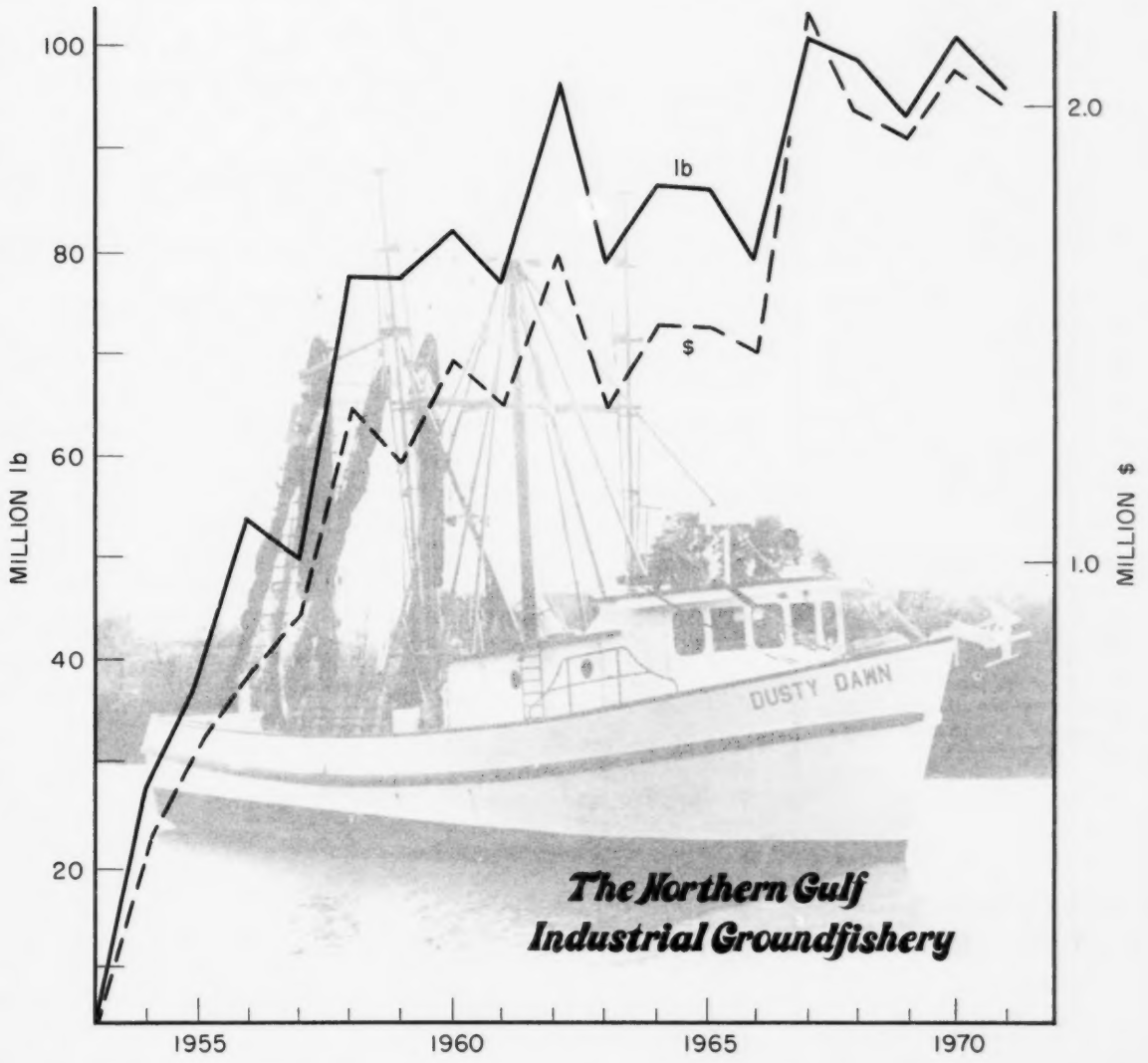

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MFR PAPER 1149

Synopsis of the Northern Gulf of Mexico Industrial and Foodfish Industries

ELMER J. GUTHERZ, GARY M. RUSSELL,
ANTHONY F. SERRA, and BENNIE A. ROHR

ABSTRACT—A synoptic overview of the industrial groundfish and croaker foodfish industries in the northern Gulf of Mexico is presented. Their histories, fishing grounds, vessels, gear, tactics, and product processing are described for the period 1952 through 1973. The fishing grounds with major species and their contribution to the fishery are discussed.

INTRODUCTION

This paper describes the industrial bottomfish and croaker foodfish fisheries of the north central Gulf of Mexico. These grounds are defined as the inshore area (out to 50 fathoms) between Pensacola Bay, Fla., and Galveston Bay, Tex. Historical and present aspects of these fisheries are considered and the techniques and tactics utilized by both fishermen and processors are discussed.

Although both fisheries exploit the same stocks, basic differences in species utilization and fishing tactics exist. The industrial bottomfish fishery produces petfood principally and to a lesser extent, bait, animal food, and fishmeal, while the foodfish fishery catches croaker for the fresh-fish market. Fishing grounds, vessels, gear, and tactics are similar but not identical between the fisheries. The industrial fishery utilizes most species and size groups, but the croaker foodfish fleet utilizes only croaker exceeding 9½ inches in length.

The northern Gulf of Mexico fauna is highly diversified with over 200 species of fish and invertebrates found on the grounds. Sciaenids—croaker, *Micropogon undulatus*; spot, *Leiostomus xanthurus*; and sea trout, *Cynoscion nothus* and *C. arenarius*—are the most important finfish in both the commercial and sport fisheries and contribute to the major portion of the industrial bottomfish and foodfish fleet catches. They also represent a major segment of the finfish discards of the shrimp fleet. Other finfish caught by the industrial fishery fleet are also utilized for petfood with the exception of sharks, skates, rays, and small catfish. Significant quantities of shrimp (*Penaeus* spp.) are also taken seasonally and substantiate the fleet income. Less desirable species may be discarded at sea in order to maintain an acceptable species composition for petfood formulation.

Croaker constitute over half of the industrial bottomfish landings and most of these croaker weigh less than ⅓ lb and are shorter than 9½ inches in length.

Croaker used by the foodfish fishery are larger than 9½ inches and are graded into three sizes: small (½ lb); medium (¾ lb); and large (1 lb). Croaker larger than 1 lb are also taken on handlines by snapper boats fishing near offshore oil rigs. In addition, a limited number of foodfish croaker are harvested seasonally from Big Lagoon, Ala.

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THE INDUSTRIAL BOTTOMFISH FISHERY

Historical Aspects

Haskell (1961) and Roithmayr (1965 a,b) have described the historical aspects of the industrial bottomfish fishery including vessels, operational methods, fishing season and area, species composition, fishing effort, catch rates, and abundance. Thompson (1966) determined the proximate chemical composition of 17 major finfish species contributing to this fishery. This information is used by the petfood industry to meet oil and protein content specification requirements for the finished product.

Bullis and Carpenter (1968) discussed the latent production of industrial bottomfish in the Gulf of Mexico, suggesting both effort and landings could be increased considerably. In fact, landings of industrial bottomfish from the northern Gulf of Mexico have increased dramatically since 1953 (Fig. 1). This increase can, in part, be attributed to the abundance and availability of sciaenid stocks inhabiting the "fertile crescent" around the Mississippi River Delta. The ready availability and abundance of these fish stimulated interest in their utilization during the early 1950's that led, in 1952, to the establishment of a pilot petfood canning plant in Pascagoula. This plant processed finfish landed incidentally to shrimp fishing operations. Fishermen were paid $22/ton—insufficient to ensure a dependable supply to the plant and many fishermen often went shrimping during periods of shrimp availability, leaving

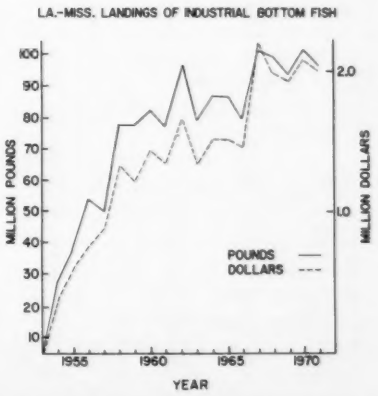

Figure 1.—Total pounds landed and dollar value of industrial groundfish from Louisiana and Mississippi for 1953-71.

Figure 2.—A contemporary Gulf of Mexico industrial bottomfish trawler.

the plant without a dependable, steady supply of finfish. Because of this, the plant began operating its own fleet in addition to contracting with independent vessels, and increased the ex-vessel price to $35/ton. The success experienced by the Pascagoula plant soon stimulated the establishment of petfood plants in Biloxi, Miss., and Golden Meadow, La.

Six million pounds of industrial bottomfish were landed from the northern Gulf of Mexico in 1952. Landings steadily increased until a plateau of about 75 million pounds was reached in 1958. Landings then fluctuated yearly but remained near this level until 1967 when production rose to about 100 million pounds (Fig. 1). This increase was due to increased Louisiana landings of industrial groundfish that doubled between 1966 and 1968, and the increased consumer demand for processed products.

Vessels and Gear

As product demand increased, processing plants needed a dependable source of fish in large quantities. Because the then-available shrimp trawlers had insufficient space for holding and refrigerating large catches, the petfood industry began to acquire vessels designed specifically to catch and hold large quantities of bottomfish.

At the inception of the fishery in 1952, the average fleet vessel was about 50 ft long with a 165-hp engine, had a hold capacity of 30 tons, and pulled a single 65-ft trawl. Gradually larger vessels ranging in length from 60 to 90 ft with a carrying capacity of from 63 to 125 tons were added to the fleet. Today, only two

Table 1.—Summary of vessel characteristics of the Mississippi industrial bottomfish fleet fishing in the northern Gulf of Mexico, 1973. This table does not represent the entire fleet; two vessels exceeding 90 feet and several vessels less than 70 feet have recently entered the fisheries.

Vessel	Tons		Length (ft)	Width (ft)	Horse-power	Winch cap. (fathoms)	Size cable (in)	Drums per winch	Winches per boat
	Gross	Capacity							
1	139	100	75	25	365	200	5/8	3	1
2	298	300	121	—	1,000	200	7/8	2	2
3	82	100	80	22	480	150	9/16	2	1
4	126	164	90	—	725	250	5/8	2	1
5	100	150	97	—	400	—	5/8	1	2
6	—	105	100	—	450	200	5/8	3	1
7	—	72	87	—	342	125	5/8	3	1
8	150	135	85	24	520	300	5/8	3	1
9	169	140	80	22	335	200	5/8	3	1
10	170	155	105	24	660	200	5/8	3	1
11	120	100	108	—	450	200	5/8	3	1

Table 2.—Summary of net characteristics of the Mississippi industrial bottomfish fleet fishing in the northern Gulf of Mexico, 1973.

Design	Length in feet		No. mud rollers	Number floats	Mesh size in inches				Meshes wing	Thread size			Loop chain link/ft	Length of leg lines (ft)	Door information		
	Head-rope	Foot rope			Wing body	Throat	Bag	Liner		Wing body	Throat	Bag			Construc. (ft)	Length (ft)	Height (ft)
2-S BN[1]	75	89	30	25	3	2	—	1¼	125	30	30	96	15	10	Wood	10	60
2-S BN	00	120	50	6	3	2	2	2¼	125	30	24	90	15	20	Steel	15	72
4-S BN	75	85	29	25	3	—	—	—	—	—	—	—	15	15	Wood	11	50
2-S FN[2]	85	100	33	24	3	1⅞	—	1¼	125	24	30	96	16	20	Wood	12	60
2-S BMFN[3]	82	90	30	33	3	3	3	1	—	30	30	96	15	20	Wood	12	72
2-S BMFN	93	111	46	23	3	1½	—	1¼	110	30	24	96	15	10	Wood	12	60
2-S BMFN	52	81	32	19	3	1	2	1	—	28	18	120	18	12	Wood	10	50
2-S BMFN	80	98	39	30	2	2	—	1½	200	21	36	96	17	14	Wood	12	60
2-S BMFN	75	89	30	25	3	2	2½	1¼	—	30	21	96	15	10	Wood	10	60
2-S BMFN	90	113	45	72	3	1½	2¼	1⅜	100	30	18	96	14	—	Steel	12	60
2-S BMFN	95	115	38	32	3	1½	2¼	1¼	190	30	30	72	15	14	Wood	12	60

[1]2-S BN = 2-Seam Balloon Net.
[2]2-S FN = 2-Seam Fish Net.
[3]2-S BMFN = 2-Seam Balloon Modified Fish Net.

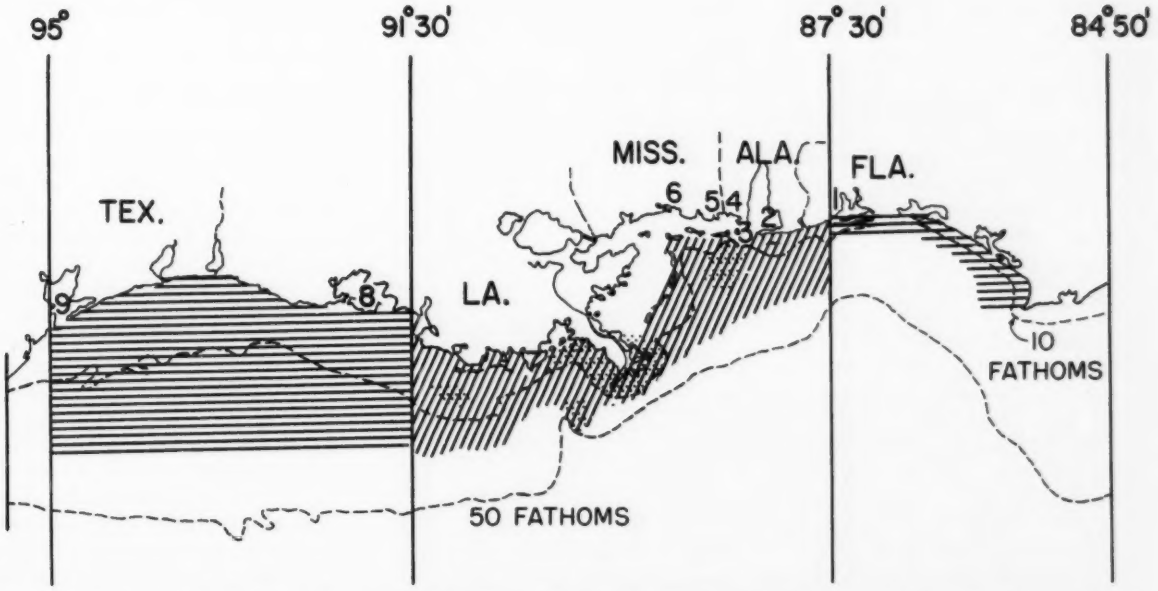

Figure 3.—Historical and traditional fishing grounds for industrial bottomfish and foodfish croaker in the northern Gulf of Mexico. Horizontal lines indicate historical grounds for industrial bottomfish while diagonal lines show the present area fished by industrial bottomfish fleet, and the stippled area is that fished by the foodfish croaker fleet. Specific locations referred to in the text are: (1) Pensacola Bay, Fla.; (2) Big Lagoon, Ala.; (3) Dauphin Islands, Ala.; (4) Bayou La Batre, Ala.; (5) Pascagoula, Miss.; (6) Biloxi, Miss.; (7) Golden Meadow, La.; (8) Marsh Island, La.; (9) Galveston, Tex.

boats still operate from the original industrial bottomfish fleet. A typical modern industrial fish trawler operating in the northern Gulf of Mexico is shown in Figure 2.

Industrial bottomfish trawlers are constructed of steel and all but two, the *Alaska* and *Falcon*, are double-rigged. Length of the vessel, horsepower, and size of towed net are variable, but generally the larger trawlers fish the largest nets. Winch capacity limits fishing depths to about 40 fathoms. All trawlers in this fleet utilize a brine-tank refrigeration system using an ammonia-cooled condenser.

At the onset of this fishery, approximately 50 boats comprised the fleet, some operating full time and some being transient. Presently, 21 boats operate full time—16 out of Pascagoula and Biloxi (Table 1 lists 11 boats of this fleet) and 5 out of Golden Meadow. Little information was available to the authors on the boats or fishing tactics of the Golden Meadow fleet. Their fishing operations are generally known to be similar to those employed by the Mississippi fleet; however, they do not venture as far offshore as the Pascagoula and the Biloxi fleets and their major effort is expended west of the Mississippi River Delta.

Important boat and gear characteristics are listed in Tables 1 and 2 for 11 of the 21 industrial bottomfish boats now operating in the fishery. Two of these boats, the *Alaska* and the *Falcon*, are converted menhaden purse seiners and have been in the fleet almost from the inception of the fishery.

Trawls used in this fishery are constructed from a single basic design, differing only in the size and arrangement of certain components. Legline length is variable, ranging between 10 and 40 ft. Mesh size is fairly uniform with 3-inch webbing in the body and wing and 1¼- to 2-inch mesh in the throat and bag. Bag liners are used with larger mesh sizes. Wing depth ranges between 48 and 200 meshes.

Trawl door size is somewhat dependent on vessel and trawl size. Doors range from 10 ft × 50 inches to 15 ft × 72 inches, with 12 ft × 60-inch doors most commonly used. Doors are generally constructed of wood, but some larger doors are constructed of steel. Steel and some large wooden doors have aluminum flotation tanks on their upper edge to provide stability.

Fishing Grounds

The shallow waters of the northern Gulf of Mexico seaward to 50 fathoms between Pensacola Bay, Fla., and Galveston, Tex., include some of the most productive fishing grounds known (Fig. 3). This area produces a wide variety and quantity of shellfish and finfish such as brown and white shrimp, (*Penaeus aztecus* and *P. setiferus*), oyster (*Crassostrea virginica*), blue crab (*Callinectes sapidus*), menhaden (*Brevoortia* spp.), and the sciaenid fishes. These marine resources support many valuable commercial and sport fisheries.

The Mississippi River exerts a major influence on the northern Gulf of Mexico industrial groundfish grounds (Gunter, 1967). The river annually deposits large quantities of sediment at its mouth, creating a soft mud bottom with a fairly steep slope. Eastward and westward from the Delta, bottom composition changes from soft mud near the river mouth to firmer mud, sand, and shell bottom.

Bottom topography east and west of the Mississippi River mouth is somewhat altered from that off the Delta because of an increased shelf area and a decreased rate of mud deposition. There, the bottom has a gentle slope with mud lumps and some "live" coral areas.

The historical industrial bottomfish fishing grounds for the northern Gulf of Mexico between 1959 and 1963 were

described in detail by Roithmayr (1965 a,b) and the present fishing grounds generally encompass the same area. The primary industrial bottomfish grounds in the northern Gulf extend seaward to about 35 fathoms but most catches are made in waters shallower than 20 fathoms. Occassionally, fishing may be conducted in depths of 40 to 50 fathoms.

Initially, fishermen seldom ventured west of the Delta because required production could be obtained near their home ports east of the Delta. During 1959-63, about 60 to 85 percent of the fishing effort and landings occurred east of the Mississippi River Delta while data from 1969-72 indicate that both effort and catch are now about equally divided between the areas east and west of the Delta (Fig. 4). This shift does not necessarily reflect geographical changes in the sciaenid population density. In all probability, this is due to the inability of the eastern grounds to meet the increased demand witnessed since 1963.

Industrial groundfish catches east of the Delta are now made primarily off the islands between Mobile Bay and North Pass of the Mississippi River. Those west of the Delta are made offshore of Grand Isle to Marsh Island, La.

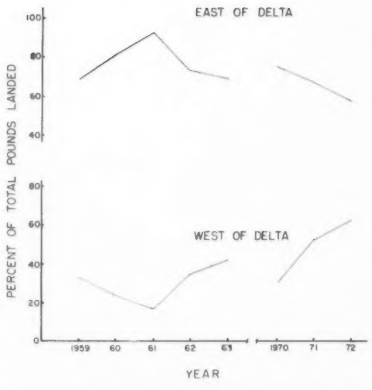

Figure 4.—Percent total production east and west of the Mississippi Delta 1959-63 (Roithmayr, 1965) and from fishing boat logbooks for 1970-72 (logbooks represent 10-15 percent of the total fleet effort).

Tactics

Fishing tactics have evolved from single rigged, small wooden vessels (average size 50 ft long with a carrying capacity of about 30 tons) to large steel trawlers (up to 130 ft long with a carrying capacity of 400 tons) designed specifically for this fishery towing two nets (Table 1).

Vessels now use outriggers that are dropped from their upright, stowed position, soon after leaving port. Each outrigger is used to tow a single trawl. The fishing trawls, prepared for operation as the vessel departs port, remain on deck until the vessel arrives at the fishing location. Brine tanks used to refrigerate the catch are filled about one-third immediately upon departure and chilling started. Additional seawater is then added and chilled as needed.

All vessels use a small trawl (approximately a 16-ft headrope) called a trynet to locate commercial concentrations of fish and to monitor the fishing activity. This is set from a separate winch and is handled independently off the stern of the fishing vessel. These small trawls use doors ranging in size from 2 ft × 18 inches to 2 ft × 24 inches. Once set, the trynet is hauled back each half hour and the catch evaluated to determine whether to: (1) continue fishing, (2) change direction of tow, (3) move to more fertile grounds, or (4) set the large fishing trawls. Appraisal criteria of the trynet catch includes species composition; number, condition, color, and ratio of croaker; and presence of undesirable species.

Significant catches of industrial bottomfish in the trynet will initiate fishing operations. When fishing two nets, the doors are hung from the end of each outrigger with the net strung out on the surface. A single winch is used for each net, which has a 30- to 50-fathom bridle extending from the tow warp to the doors. As the doors are dropped into the water the nets spread, assuming their fishing configuration as they are carried to the bottom. Single-net fishing, on the other hand, is done off the stern with one door hung from a gallows on each side of the vessel. Two winches and tow warps are used; the bridle is absent. The net is laid out behind the boat and when the doors are dropped it assumes its fishing attitude. Maintaining tension on the towing cable is very important during setting to ensure that the trawl is properly spread. Warp length is approximately four times the bottom depth unless fishing in shallow water (5 fathoms or less) where the scope ratio is increased to five or six times the depth. When fishing in 2 or 3 fathoms, the fishermen lets out only enough warp to submerge the entire bridle.

Trawling time is quite variable, depending upon density and availability of

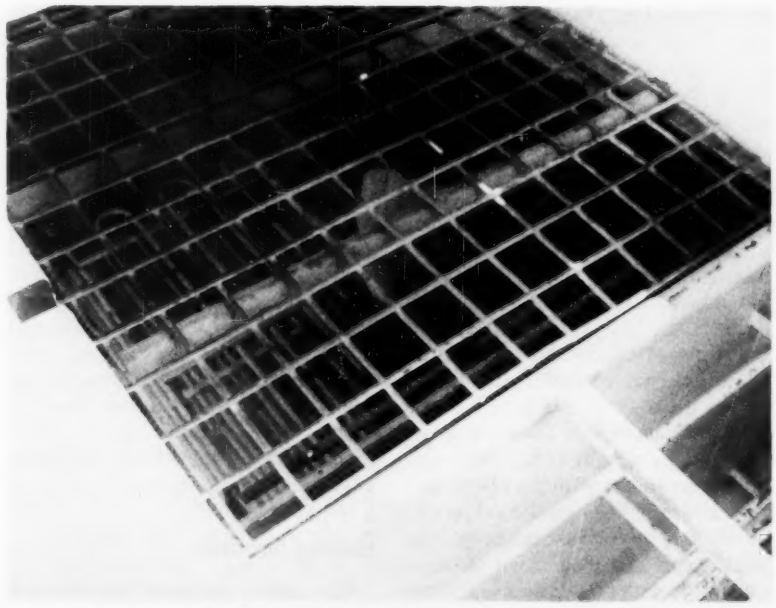

Figure 5.—Grid array used over hatches on the industrial bottomfish trawlers to prevent large specimens from entering the brine tanks.

finfish on the grounds. Towing time ranges between 10 min and 5 h but averages about 3 h per tow. Longer tows ordinarily produce catches of inferior quality because of the abrasions caused by other fish, the webbing, and water pressure. When catch rates are high, fishing is conducted both day and night unless sea conditions limit operation. Non-fishing time is restricted to search and repair functions. If fish are scattered and catch rates low, many vessels stop fishing overnight and continue at daybreak.

After a tow has been completed, the trawl is swung over a sorting grid above the hatch and the catch emptied directly into the chilled brine maintained between 28° and 30°F (Fig. 5). This process immediately raises the brine temperature; however, the solution stabilizes downward to 28°-30°F in about 15 min. Large fish will not enter the fishhold because of the sorting grids and of these, undesirable species are discarded and edible fish saved for future sale.

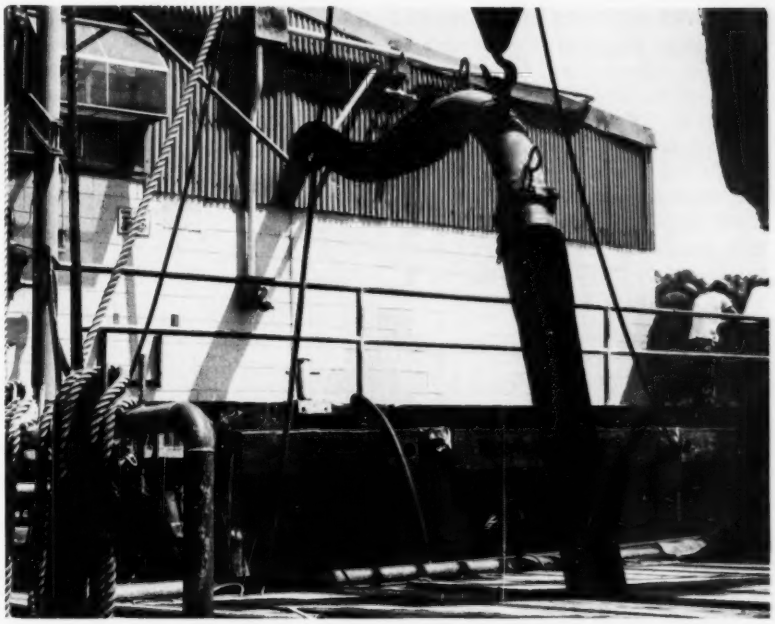

Figure 6.—Suction hose used to offload industrial bottomfish catches at the processing plant.

Trip duration has changed since the early years of the fishery when a trip lasted from 1 to 3 days and the vessels fished reasonably close to the plant sites. Today, trips average about 7 days and range from 3 to 10 days, depending on catch rates and vessel capacity. Running time to the grounds used to vary from 1 to 6 h, but can now take up to 24 h. Fishing time averages about 14 h per day but is variable depending on bottom type, density of stock, and incidence of repairs. Processors request that vessels do not remain at sea longer than 7 days to prevent reduced catch quality.

Gear damage on the grounds due to bottom type or obstructions is relatively light because of the regularity and texture of the bottom. There is, however, a serious threat to trawls from sharks and large jacks (*Caranx hippos*), particularly close to the Mississippi River mouth. Large schools of sharks abound in that area and at times tear large holes in the trawl body or codend. Fishermen have reported that large schooling jacks, (a species that does not have the extensive dentition of sharks) can also do considerable damage to a net through repeated strikes that weaken the net twine.

Trawl damage and subsequent catch loss is costly and large concentrations of sharks can force vessels to leave a high-production area. This has stimulated the development of several techniques to reduce both severity and incidence of trawl damage by fish. Mesh sizes larger than 3 inches have been used, but fish gilling attracts sharks and increases the incidence of damage. Electrical shocking units placed on the bag were successful in discouraging sharks but their usefulness was overridden by the risk of loss and high cost. Stainless steel chaffing bag covers, which slip directly over the trawl, have had some success against sharks, but with prolonged use they abrade the twine and weaken the bag. Regardless, these chaffing bags have been more successful than any other shark deterrent and are used by many fishermen.

Processing

Vessels are offloaded with a hydraulic fish pump (Fig. 6) that transfers fish and chilled brine from the hold onto a conveyor belt leading into the plant. Fish are transported into the plant, but the brine solution is recycled back into the hold and is repeatedly removed with fish by the hydraulic fish pump unit. Offloading time is variable, depending on species composition, size of fish, and weight of catch. Offloading 100 tons of fish will take from 6 to 8 h unless the belt must be repeatedly stopped to remove edible or undesirable species. Edible fish, crustaceans, trash, and all undesirable animals (i.e., those difficult to grind or harmful to grinders) are removed from the belt as the catch moves into the processing area. Edible items are returned to the boat to be sold or eaten by the trawler crew, and the undesirable species discarded. Usable fish continue into the petfood processing area.

Processing, generally similar throughout the industry, includes grinding, mixing, cooking, fortifying, canning, sterilizing, labeling, and casing. Whole raw fish are ground and mixed with meal or other animal protein. Vitamins, minerals, and other products are added according to specified formulation. The product is then cooked, canned, sterilized in retorts, cooled, labeled, and readied for distribution.

Some handling differences occur depending on plant and degree of automation. For example, one plant initially handles the catch on the deck, whereas the other plants do not handle the catch until it has entered the processing area. Sterilization techniques also differ among processors, some requiring considerably more manual effort in placing and removing cans in the retorts.

FOODFISH CROAKER FISHERY
Historical Aspects

Declining croaker catches in the Chesapeake Bay area (Joseph, 1972) resulted in a ready market for large Gulf croaker and stimulated in 1967 the establishment of a foodfish fishery in Bayou La Batre, Ala. Landings have increased significantly each year from 1967 to 1971, with 10 million lb valued at $1 million landed in 1971 (Fig. 7).

A foodfish fishery for croaker was not initiated in the Gulf of Mexico before 1967 because quantities of large croaker, capable of sustaining a fishery, were unavailable though croaker exceeding 1 lb were known to be present in the inshore and offshore waters of Texas, Louisiana, Mississippi, and Alabama. Those few taken were generally sold in local fresh-fish markets. In 1967, large croaker appeared in sizable quantities in 5 fathoms and deeper around the mouth of the Mississippi River, and a portion of the local shrimp fishing fleet began fishing for them on a regular basis.

Their "sudden" appearance, in sufficiently large quantities to establish a fishery, has not been adequately explained. It has been suggested that the croaker population, prior to exploitation by the industrial bottomfish fishery, was stunted due to overpopulation. Initiation of the industrial bottomfish fishery and its subsequent landing eliminated overpopulation, thereby allowing croakers to grow to their "normal" size. In addition, the presence of offshore oil platforms on these grounds may provide "refuge" for these fish, thereby reducing exploitation and allowing them to grow to a larger size. This view is not shared by all fishermen. Some industrial groundfish fishermen have advocated that lack of a market for large croaker is the primary reason that

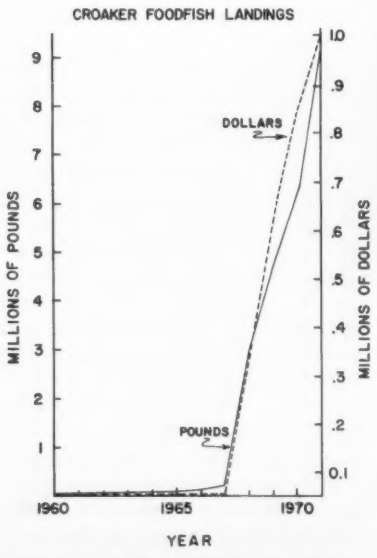

Figure 7.—Total pounds and dollar value of foodfish croaker landed through 1971.

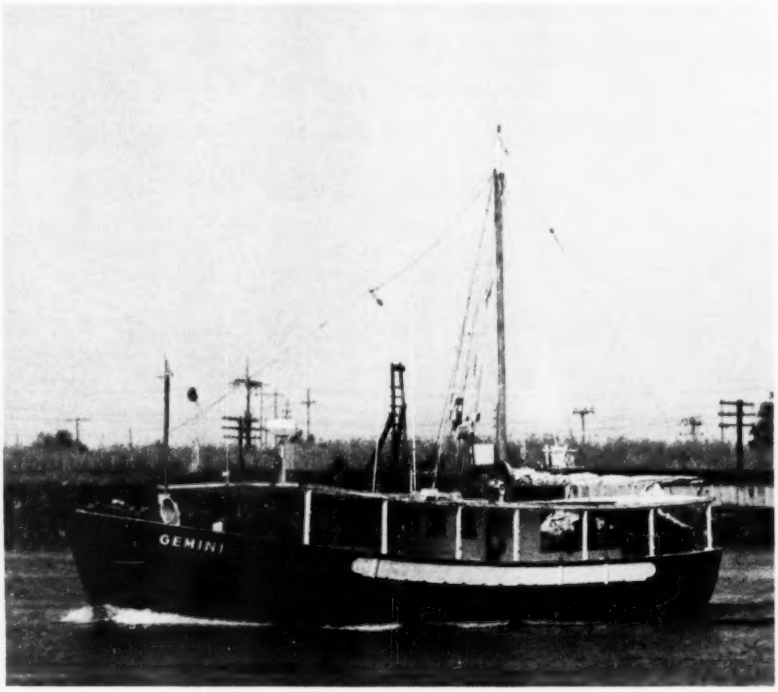

Figure 8.—Conventional handline snapper fishing boat.

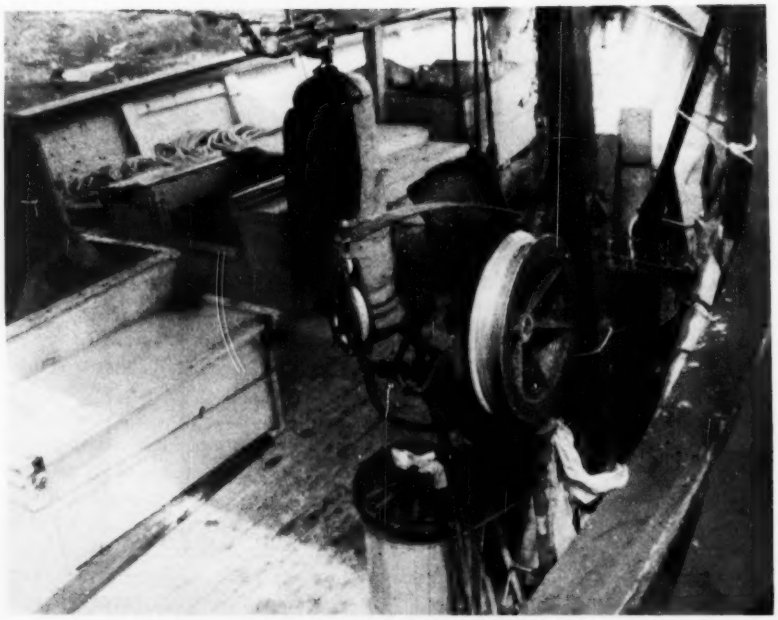

Figure 9.—Snapper boat handlines and reel.

few were landed prior to 1967. They state that prior to the establishment of the foodfish fishery, large croaker catches could be made off the mouth of the Mississippi River; however, industrial products processors discouraged the catching of these large croaker. Despite these theories, the origins of the sudden rise in foodfish croaker populations remain obscure at this time.

Some 10-20 thousand lb of foodfish croaker are also taken annually by trammel nets in Big Lagoon, Ala. This operation is independent of the trawl fishery, the catch being sold directly to outside markets by the producer. Limited numbers of large croaker are also taken on handlines by snapper boats fishing offshore oil platforms around the river mouth but principally west of Southwest Pass. A typical snapper handliner is shown in Figure 8. Standard snapper reels baited with squid or cut fish are used in this activity (Fig 9).

Approximately 75 percent of the foodfish croaker landed are taken by trawlers who fish primarily for croaker, whereas the remaining 25 percent is taken by shrimpers who occasionally trawl for croaker. This distribution of effort into either shrimp or croaker is a matter of degree and is, in part, influenced by the availability and/or price of either resource.

Vessels and Gear

Vessel and gear characteristics for the foodfish trawler are given in Tables 3 and 4. Initially, the local foodfish croaker fleet was comprised of large shrimp boats, but vessel modifications were required as catches increased. These modifications were primarily directed toward handling larger, more efficient trawls and increasing the holding capacity. A typical foodfish trawler operating in this fishery is shown in Figure 10.

All but one of the primary trawlers in this fleet are constructed of steel, the other of wood. Refrigerated ice, rather than brine, is used to maintain better catch quality. Vessel length, horsepower, and net size are less variable than in the industrial fleet and all are equipped for double-rigged trawling.

Trawls used by the foodfish fleet are of one basic design. These are generally smaller than those used in the industrial fishery (though rigged the same)

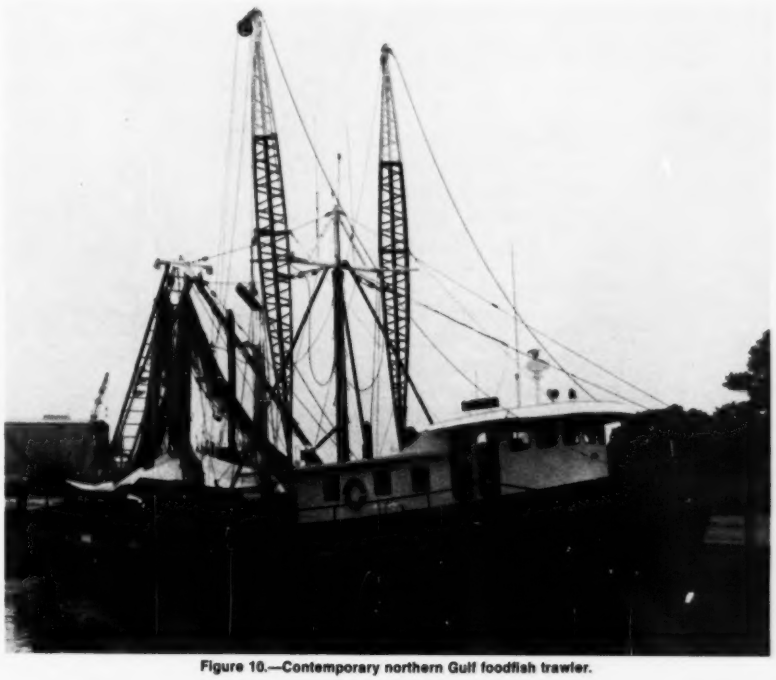

Figure 10.—Contemporary northern Gulf foodfish trawler.

Table 3.—Summary of vessel characteristics of the foodfish croaker fleet fishing in the northern Gulf of Mexico. This table represents the principal croaker foodfishing vessels.

Vessel	Type construction	Tonnage		Length (ft)	Width (ft)	Horsepower	Winch capacity (fathoms)	Size cable (in)	Drums per winch
		Gross	Capacity						
1	Steel	137	93	83	29	320	200	5/8	3
2	Steel	114	101	75	21	320	200	5/8	2
3	Steel	77	52	65	20	340	200	3/8	—
4	Steel	135	93	85	20	425	—	5/8	—
5	Steel	118	81	75	21	420	200	5/8	3
6	Steel	115	78	80	22	375	200	5/8	3
7	Steel	119	81	83	24	320	245	5/8	3
8	Steel	119	85	85	24	320	200	5/8	3
9	Steel	115	78	75	22	340	225	5/8	3
10	Steel	114	67	72	22	345	200	5/8	3
11	Wood	79	53	70	20	240	200	5/8	3
12	Steel	136	92	86	24	425	1,000	5/8	3

Table 4.—Summary of net characteristics of foodfish croaker fleet fishing in the northern Gulf of Mexico, 1973.

Length (ft)					Mesh size in inches								Chain arrangement			Leg	Door information	
Head-rope	Foot-rope	No. of rollers	Floats No.	Floats Type	Wing body	Throat	Bag	Meshes in wing	Wing	Body	Throat	Bag	ft. between loops	Links/ loop	Texas drop	line (ft)	Length (ft)	Height (ft)
65	75	35	12	Plastic	2	1½	1⅛	150	18	21	30	54	7	20	—	12	10	40
65	75	38	7	"	2	1½	1½	150	21	21	21	54	7	—	8"	12	10	44
52	62	26	4	"	1⅞	1⅝	2	100	18	18	—	54	3	—	—	12	9	40
65	75	38	4	"	2	1½	1½	125	18	21	21	54	4	—	—	12	11	44
65	70	30	5	"	2	1½	1½	135	21	21	21	54	4	15	—	10	10	44
65	75	35	8	"	2	1½	1½	100	21	30	30	54	4	18	—	10	11	44
62	72	35	8	"	2	1½	1½	80	21	30	30	54	4	16	—	16	10	44
60	70	20	10	"	2	1½	1⅞	200	18	30	18	54	10.5	16	—	15	10	44
62	72	22	5	"	2	1½	1⅝	165	21	30	30	54	4	15	—	10	10	44
71	81	24	5	"	2	1½	1⅞	125	18	21	21	60	9	17	—	12	10	44
50	60	25	6	"	2	1½	1⅞	100	18	30	30	54	6	16	—	12	9	40
65	70	33	18	Sponge	2	1½	1½	100	21	30	30	54	1	14	—	6	12	44

and range in headrope length from 40 to 71 ft (Table 4). Size used is somewhat dependent upon vessel size and horsepower. The variation between the number and type of floats and mud rollers used is shown in Table 4. Placement of floats, mud rollers, tickler chain, and drop chain is variable, depending on the captain. Trawl thread and mesh size are fairly uniform throughout the fishery but wing depth does vary between 80 and 200 meshes, depending on how high from the bottom the captain wants the net to fish. The most commonly used trawl doors are 10 ft × 44 inches, of wood and chain construction.

Fishing Grounds

The present fishing grounds are shown in Figure 3. The primary fishing area for trawl-caught foodfish croaker is around Southwest Pass off the Mississippi River Delta, with limited fishing conducted between Southwest Pass and North Pass in depths of 5 to 40 fm and in the area between Southwest Pass and Marsh Island in depths to about 20 fm. As mentioned, the handline fishery is located near offshore oil platforms in depths of 20 to 39 fm, and the fish are generally larger than the "large" trawl-caught croaker. Handlined croaker average about 2 lb in weight and 18 inches in length, whereas the large trawl-caught croaker weigh 1 lb and are about 15 inches long.

Tactics

Major differences between industrial bottomfish and croaker foodfish fishing lie in the size of fish harvested and the shipboard processing techniques employed. The foodfish industry requires only croaker larger than 9½ inches that have been held on ice for short periods. Croaker between 9 and 10 inches are least desirable though improved mincing techniques may allow using this size croaker in such products as fish blocks, etc.

A similar but smaller trynet than that used in the industrial fishery is used to locate commercial concentrations of foodfish-sized croaker and to monitor availability and density of croaker. Trynet operation in both foodfish and industrial bottomfish fisheries is similar. Fishing operations with the large trawls are as described in the section titled Industrial Bottomfish Fishery.

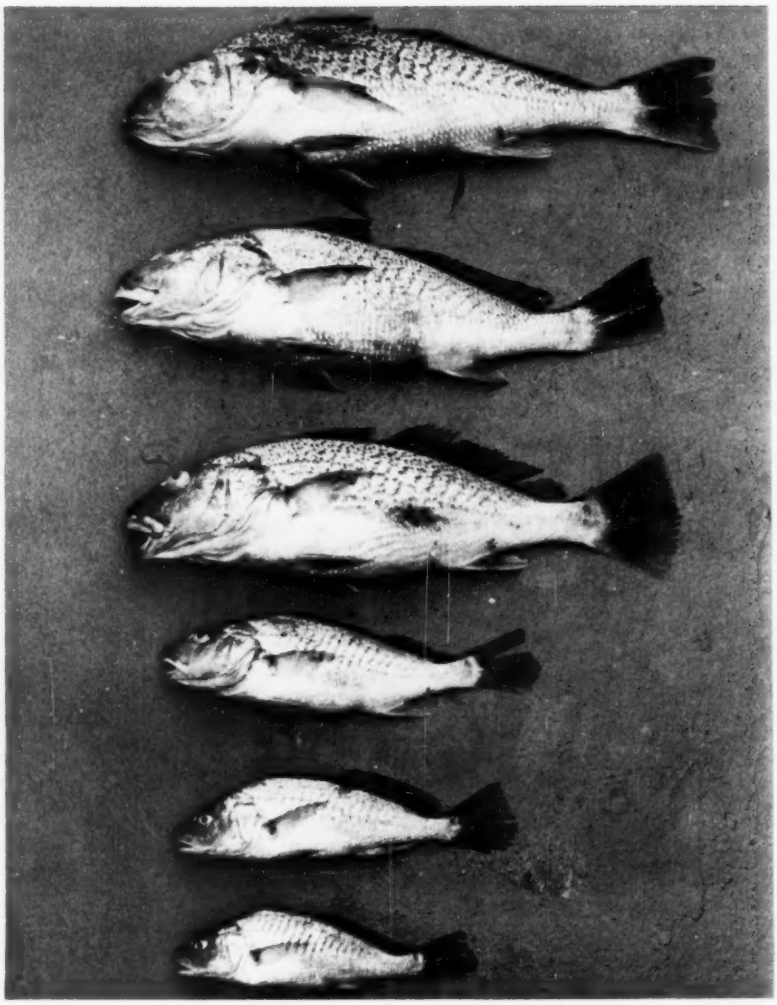

Figure 11.—Foodfish croaker taken in the northern Gulf of Mexico on the National Marine Fisheries Service RV *Oregon II*. Lower two fish are small foodfish, middle two fish are medium foodfish, and upper two are large foodfish.

Drag time varies from 20 min to 3 h, depending upon the concentration of available food-sized croaker. Trawling is conducted only between sunrise and sunset because fishermen believe that fishing in the same area continuously for 24 h unsettles the bottom and drives the fish from the area.

After the bag is brought aboard and emptied on deck, the catch is sorted for foodfish croaker, other foodfish species, and shrimp. Usable croaker are rough-sorted into large-, medium-, and small-sized groups and put into the hold and iced (Fig. 11). Large foodfish-sized croaker weigh over 1 lb and are longer than 12 inches; medium-sized croaker are between ¾ and 1 lb and are longer than 10 inches; small-sized croaker are between ½- and ¾-lb and are longer than 9 inches. Marketable fish and shrimp are put into the hold in separate bins and iced. The remainder of the catch is discarded and the net reset.

Trip time ranges between 3 and 12 days depending on availability and density of foodfish-sized croaker and/or weather. An average trip lasts about 6.7 days, with 5 days of fishing, and the remainder spent traveling. Fishing time per day is about 13 h minus search and repair time. This fishery experiences the same problem with sharks and large jacks as discussed in the section titled Industrial Bottomfish Fishery.

Processing

Processing operations are generally similar throughout the trawl-caught foodfish croaker industry. Croaker are offloaded separately from other edible fish using either a large bucket or a suction pump which removes both ice and finfish from the hold. Except for minor differences, both systems utilize a conveyor belt to transport the catch into the plant; however, when the suction pump is used the catch is deposited directly onto a conveyor belt, but when a bucket system is employed the catch is first dumped into a water tank hopper and then automatically carried onto the conveyor belt (Fig. 12).

The catch entering the plant is hand-separated into the three foodfish-sized groups (Fig. 13). The sorted fish are then boxed in the round and iced for transport to the fresh-fish markets in Chesapeake Bay and New York.

Croaker are offloaded from snapper boats with a suction pump, but hand-sorting into size groups is obviously unnecessary. These croaker are boxed, iced, and transported to Bayou La Batre for shipment to the northeastern markets.

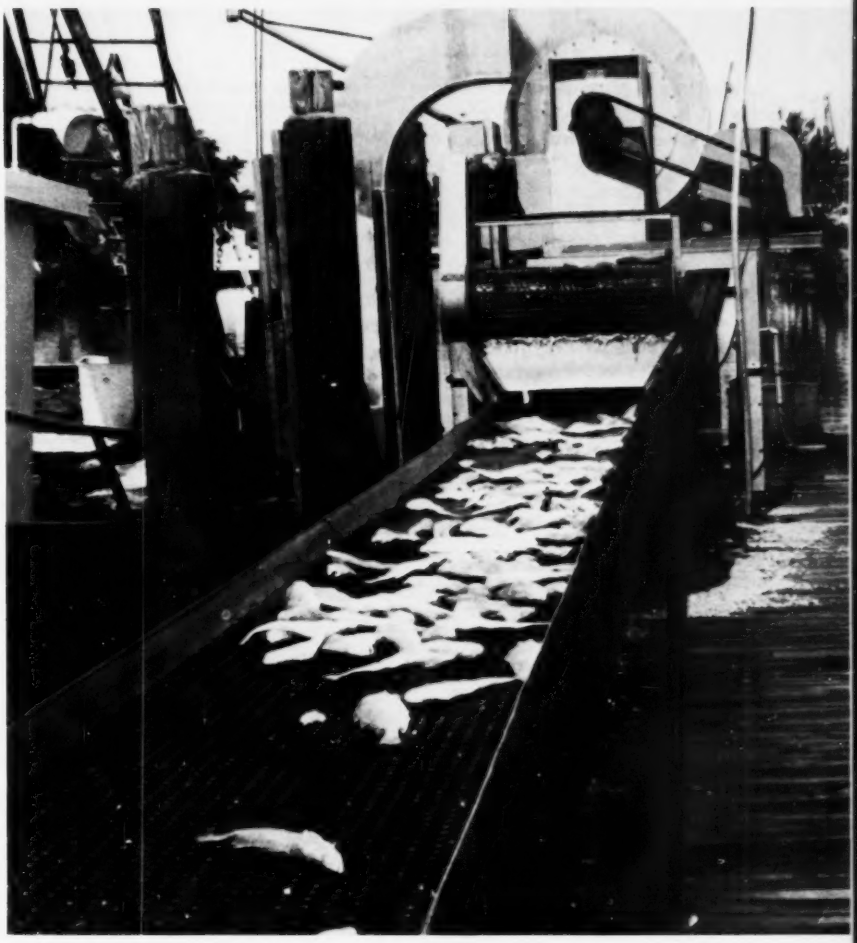

Figure 12.—Conveyor belt used in offloading vessels.

FINFISH DISTRIBUTION ON THE NORTHERN GULF OF MEXICO FISHING GROUNDS

Finfish distribution on the northern Gulf grounds is variable and somewhat dependent on bottom type, water temperature, and season, as evidenced by changes in catch rates and species composition. Croaker, the largest component of the commercial catch, prefer a mud bottom and are generally not found in depths exceeding 60 fathoms. Few croaker or other sciaenid fishes are caught over a sand/dead-shell bottom.

The depth at which quantities of fish are found is dependent, in part, on water temperature and season. Heavy concentrations of fish occur in shallow, warm water (inside 10 fathoms) during the summer months, but in fall and winter croaker and spot move offshore to about 40 fathoms (Franks et al., 1972). This offshore migration is partially in response to the cooling of the shallow inshore waters during the colder winter months.

Croaker and other finfish are not evenly (i.e., non-randomly) distributed

Figure 13.—Hand sorting and grading foodfish croaker.

on the fishing grounds. This is demonstrated by the often-encountered high variability in catch rates between simultaneously-towed nets. Enormous croaker schools are occasionally encountered where fish extend from the surface to the bottom. Fishermen, locating these concentrations by the large mud roils that are created, have reported catches of from 10 to 20 tons of croaker in 10-15 min of fishing. Because croaker tend to be concentrated in large schools whose general distribution is uneven, "staying in fish" becomes quite difficult and distribution and density must be continuously monitored to optimize vessel operations. Losing the schools results in costly search time with a subsequent increase in operational expense. Thus, the trynet is used to reduce this expense.

SPECIES COMPOSITION

A list of species taken on the northern Gulf of Mexico bottomfish grounds has been published by Roithmayr (1965 a). Only 10-20 species represent major components of this fishery (Table 5). The total species composition on the grounds remains constant, though temporal and spatial changes in species ranking are detected from trawl samples. Studies are presently underway by the National Marine Fisheries Service to gain an understanding of these fluctuations and the mechanisms responsible for them.

Species composition differs seasonally inshore-offshore and east and west of the Mississippi River Delta (Moore, Brusher, and Trent, 1970). Those species exerting a distinct influence on the finfish biomass are listed in Table 5. Sciaenids strongly dominate species composition, and at times, catches are almost exclusively one or more of the following seven species: croaker (*Micropogon undulatus*), spot (*Leiostomus xanthurus*), silvereel (*Trichiurus lepturus*), catfish (*Arius felis*), longspine porgy (*Stenotomus caprinus*), bumper (*Chloroscombrus chrysurus*), or butterfish (*Peprilus burti*). Often these seven species can account for as much as 95-98 percent of the total weight of the catch.

Brown, white, and pink shrimp (*Penaeus aztecus*, *P. setiferus*, and *P. duorarum*) are at times taken in quantities that represent a significant dollar value to the fisherman. Seasonally, large quantities of pompano (*Trachinotus carolinus*) and bulldozer lobster (*Scyllaridae*) are taken with the industrial finfish catches, and are sold on the local fresh-fish market or consumed by the fishermen.

Table 5.—List of the finfish species contributing a significant portion of the catch taken on the industrial and foodfish croaker grounds of the northern Gulf of Mexico.

Family	Scientific name	Common name
Sciaenidae	*Cynoscion aurenarius*	Sand seatrout
	Cynoscion nothus	Silver seatrout
	Larimus fasciatus	Banded croaker
	Leiostomus xanthurus	Spot
	Menticirrhus americanus	Southern kingfish
	Micropogon undulatus	Croaker
	Stellifer lanceolatus	Star drum
Carangidae	*Chloroscombrus chrysurus*	Bumper
	Trachurus lathami	Rough scad
	Vomer setapinnis	Atlantic moonfish
Ariidae	*Arius felis*	Sea catfish
Sparidae	*Stenotomus caprinus*	Longspine porgy
Stromateidae	*Peprilus burti*	Gulf butterfish
Trichiuridae	*Trichiurus lepturus*	Atlantic cutlassfish (Silvereel)
Clupeidae	*Harengula pensacolae*	Scaled sardine
	Sardinella anchovia	Spanish sardine
Synodontidae	*Synodus foetens*	Lizardfish
Triglidae	*Prionotus* sp.	Searobin

SUMMARY

The finfish resource of the northern Gulf of Mexico, dominated by sciaenids (croaker, spot, seatrout), supports two major trawl fisheries. One, initiated in 1952 to produce petfood, has undergone significant changes in vessels, gear, and fishing tactics. The second, begun in 1967, produces croaker for human consumption. Both fisheries use steel (one wood vessel exists in the industrial fishery) trawlers ranging from 65 to 121 ft and equipped for double-rigging trawling. Fishing gear is very similar in both fisheries and each uses the small "trynet" as a monitoring tool.

Major differences between the two fisheries (aside from the marketed product) lie in the species utilized, size of croaker required, and the processing and holding technology used at sea. The industrial fishery uses most finfish taken and requires croaker less than 8 inches in length. The catch is held at sea in chilled brine. Conversely, the foodfish fishery uses only croaker and those must exceed 9 inches. Catches are held in refrigerated ice. Both fisheries sort out and save edible finfish and shrimp for separate onshore sale.

Foodfish croaker are graded as small, medium, and large with preference for fish over 1 lb. The fishery is supplemented by handlined croaker, exceeding 1 lb and often much heavier, taken by commercial red snapper vessels near offshore oil platforms.

Fishing grounds extend from Pensacola, Fla., to Galveston, Tex. The primary grounds are located around the mouth of the Mississippi River and within 50 miles east of North Pass and 100 miles west of Southwest Pass. Fishes are generally found inshore (shallower than 12 fathoms) during the warm summer months and further offshore (30 to 40 fathoms) during the colder winter months.

Finfish stocks, particularly croaker, are distributed non-randomly on the grounds. At times they form excessively large schools from which fishermen report making catches up to 20 tons in about 10 to 15 min. Sciaenids such as croaker, trout, and spot are so dominant in the resource that they often make up as much as 98 percent of the catch. In 1972 the combined landings from these two fisheries exceeded 100 million pounds.

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[1]Reference to trade names does not imply endorsement of the National Marine Fisheries Service, NOAA.

Bosarge, Robert Shell, E. Kent Seaman, Henry A. Seam, Billy Blande, Lloyd Hunter, Sang Langinais, Earl Skinner, Billy Marshall, and Henry Joe Moore. Many others also contributed information and assistance, and to these we express our gratitude.

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MFR PAPER 1150

Economic Impact of Commercial Shrimp Landings on the Economy of Texas

WADE L. GRIFFIN and LONNIE L. JONES

INTRODUCTION

The Gulf Coast shrimp resource supports a large and expanding industry. The value of 1971 shrimp landings was estimated at over $136 million, more than 80 percent of the total U.S. shrimp catch[1]. Commercial fish landed in Texas in 1971, most of which was shrimp, was valued at $70 million. Shrimp landed in Texas is a very large percentage of the Gulf of Mexico landing. This implies that the waters adjacent to Texas are quite productive for shrimp and that these shrimp are important to the economy of Texas.

The economic contribution that shrimp producers make to the local economy and to the state of Texas is of interest since the resources of the Gulf and bays of Texas are used by many groups for both recreational and commercial purposes. Each year various groups increase their demand for the resources of the Gulf and bays. Since the Gulf and bays do not have an infinite capacity to satisfy this increased demand, the various groups become competitive for the resource. As groups become more and more competitive, one may conclude that some or all of these groups will be limited in their use of the resource. For example, if waste disposal occurs to the extent that other activities are precluded, the disposers of waste will have, in effect, appropriated the resource. The same concept applies when any special interest group uses the Gulf or bays to the exclusion of others.

The use of the Gulf and bay resources could be decided either by such a process of elimination or by public policy. Development of public policy means that state and local organizations and federal agencies will be confronted with decisions which may affect the shrimp resource as well as other resources of the Gulf. Among the factors that should be considered in decision making is the economic contribution that each group of users makes toward the welfare of society. This report focused on the economic contribution that shrimp producers make to Texas in order to evaluate the potential economic value of shrimp production[2].

PROCEDURE, STUDY AREA, AND DATA DESCRIPTION

Procedure

The statewide impact from shrimp production is estimated through economic multiplier analysis. Conceptually, the multiplier can be explained as follows. Shrimp fishermen buy various goods and services in order to fish for shrimp. They also receive wages that are spent to support their families. The people who provide these goods and services use a portion of this payment to pay wages and salaries and buy material to replace the goods purchased by the shrimp fishermen. These purchases in turn will result in more purchases. The economic impact of the initial purchases made by shrimp fishermen permeates the economy. Multipliers are a condensed measure of how much economic activity is generated by such initial purchases. These multipliers have been estimated and are available from input-output models recently developed within Texas (Grubb, 1973 a, b). Multipliers that are useful to the understanding of the details of how initial economic activities affect the economy and that are used in this study are: output, income, and employment. The shrimp industry output multiplier, as used in this report, is an estimate of the total amount of output from all sectors of the economy required to support one dollar of output in the shrimp industry. The income multiplier is an estimate of the total quantity of income (salaries, wages, profits and rent) paid to households per dollar income payment made by the shrimping industry. The shrimp industry employment multiplier is an estimate of the total employment in the economy that results from shrimp industry output expansion sufficient to require an additional employee to be hired.

Data Description

The data used in this study are from two sources. First, 5-year series of production- and price-data collected by the National Marine Fisheries Service (NMFS) and analyzed by Griffin[3] provided estimates of the value and total weight of shrimp landed in Texas ports during the 1967-1971 period. Second, output, income, and employment multipliers were adapted from the 1967 input-output model of the State of Texas (Grubb, 1973b[4]).

[1]Griffin, Wade L., John P. Nichols, and Ronald D. Lacewell, "Trends in Catch/Effort Series: Gulf of Mexico Shrimp Fishery." Texas Agricultural Experiment Station, Department of Agricultural Economics, Texas A&M University, College Station, Tex. Dec. 1973, 85 p. Unpublished report, National Marine Fisheries Service, NOAA, under NMFS Contract No. 03-3-042-19.

[2]For the complete report, see Sea Grant publication TAMU-SG-75-204, Center for Marine Resources, Texas A&M University, College Station, TX 77843.

[3]Griffin, Wade L., David Smith, Ronald D. Lacewell, and John P. Nichols, "National Marine Fisheries Service Shrimp Landings Description of Data Availability." Department Information Report No. 73-3, Texas Agricultural Experiment Station, Department of Agricultural Economics, Texas A&M University, College Station, Tex. Jan. 1973, 17 p.

[4]Multipliers were actually developed for "fisheries." However, since the value of shrimp landed constitutes approximately 90 percent of the total value in the "fisheries" landings in Texas, these multipliers are appropriate for estimating the impact of shrimp industry output.

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These data were used in combination to develop the estimates of total output, income and employment impacts for the state, that result from output and purchases made by the shrimp industry.

TOTAL OUTPUT OF THE SHRIMP INDUSTRY

Table 1 shows the total output of shrimp in pounds and value for the state of Texas for the period 1967-1971. Production and value figures for 1971 are used in this analysis since they were the most recent figures available at the time this study was conducted and because shrimp output for that year corresponds closely to an average year's production[5]. The total output of the Texas shrimp industry in 1971 was 54.2 million pounds and its total value was $63.9 million.

Table 1.—Pounds and value of shrimp landed in Texas from 1967 through 1971.

Year	Total	
	Pounds[1]	Value[2]
1967	63,663	$45,968
1968	52,333	45,872
1969	44,485	43,024
1970	55,402	34,373
1971	54,230	63,921

[1]Heads-off weight in hundreds of pounds.
[2]Values listed in thousands of dollars.

DIRECT IMPACT OF THE TEXAS SHRIMP INDUSTRY

The direct impact of the shrimp industry on the remainder of the economy is demonstrated by the value of its estimated purchases from all other major economic sectors. Table 2 shows how the value of shrimp industry output in 1971 was used for purchases of productive inputs such as food processing, petroleum, shipbuilding, households, taxes, depreciation, and goods and services imported into Texas. Since the shrimp industry is labor-intensive, the largest component in each case was payments to households for labor and managerial services. For Texas, it is estimated that from a total value of production of $63.9 million, the industry paid $24.0 million to households or over 37 percent (Table 2). Significant purchases of inputs and services also were made from industries such as food processing ($2.1 million), petroleum products ($2.8 million), shipbuilding ($5.6 million) and others.

Table 2 indicates only the direct purchases by the shrimp industry from the economies of the State. Hence, they indicate only part of the total impact of the industry on the economy. Direct purchase by the shrimp industry from input-supplying industries stimulates output and subsequent purchases by those industries. In turn, these output changes give rise to more secondary and tertiary output responses in related industries. These indirect impacts, as well as the output increases induced by expenditures made by employees who receive income from the shrimp industry, are included in estimates of the aggregate (direct, indirect, and induced) economic impact and are expressed in terms of output, income, and employment multipliers.

AGGREGATE ECONOMIC IMPACT OF THE TEXAS SHRIMP INDUSTRY

Economic Output

The economic impact of the Texas shrimp industry is estimated on the basis of both the per-dollar output and the aggregate dollar output of shrimp. As shown in the second column of Table 3, $1.00 of output by the shrimp industry has a total economic output impact on the Texas economy of $3.08. This includes $1.00 of output by the shrimp industry and $2.08 of indirect and induced output by supporting industries. Related production by major sectors of the economy includes: 10 cents for food processing, 7.5 cents for petroleum products, 10.5 cents for wholesale trade services, 19.0 cents for retail trade, 13.3 cents for financing, etc. to support $1.00 of shrimp industry production. These are total outputs required of each industry, including secondary and tertiary production requirements per dollar of shrimp industry output. Total income payments to households by all industries of about 89 cents are stimulated by the initial $1.00 of shrimp production. Payments go to households throughout the state from all industries in the form of salaries, wages, profits, and rents as a result of $1.00 of shrimp production and the outputs required by supporting industries.

The total value of shrimp production to commercial shrimpers for Texas landed shrimp in 1971 was estimated to be $63.9 million. The total estimated output impact of this production on each major sector of the economy is presented in column 3 of Table 3. The aggregate impact values are estimated by multiplying the total value of shrimp output by the output impact on each major industry per dollar of shrimp output. For example, it is estimated that $63.9 million output value stimulated $6.5 million value of output in the food processing industry, $4.8 million in petroleum products, $12.1 million in retail trade, $56.8 million in household income, etc. In total, the estimated direct,

Table 2.—Direct purchases by the shrimp industry from major economic sectors of Texas, 1971.

Industry	Texas (thousands)
Agriculture and forestry	$ 9
Shrimp	589
Crude oil and natural gas	57
Food processing	2,072
Textiles	628
Wood and paper	8
Paints and cleaners	76
Petroleum products	2,847
Shipbuilding	5,611
Other manufacturing	150
Transportation	1,590
Communications	126
Utilities	132
Wholesale trade	2,063
Retail trade	1,046
Finance	1,003
Insurance	1,905
Services	554
Households	23,961
Property payments	7,243
Taxes	1,471
Depreciation	5,641
Imports	5,138
Total	$63,921

Table 3.—Economic impact of the shrimp industry's $63.9 million of output on the economy of Texas, 1971.

Industry	Impact per dollar of shrimp output	Aggregate impact by the shrimp industry (millions)
Agriculture and forestry	$0.0477	$ 3.05
Shrimp	1.0000	63.92
Crude oil and natural gas	.0433	2.76
Food processing	.1016	6.49
Textiles	.0163	1.04
Wood and paper	.0260	1.66
Paints and cleaners	.0025	.16
Petroleum products	.0753	4.81
Shipbuilding	.0891	5.69
Other manufacturing	.0634	4.05
Transportation	.0618	3.95
Communications	.0214	1.36
Utilities	.0433	2.77
Wholesale trade	.1045	6.68
Retail trade	.1898	12.13
Finance	.1334	8.52
Services	.1762	11.26
Households	.8896	56.84
Total	$3.0852	$197.12

[5]Production in 1971 is approximately equal to the 5-year average (1967-71). This is also evidenced in a study by Griffin, et al., (footnote 1, Figure 21, p. 41).

indirect, and induced impact on the Texas economy of the value of 1971 shrimp production was $197.1 million.

As these results indicate, the contribution of the Texas shrimping industry to the State's economy is significant. Almost $200 million is generated as a result of direct production, purchases made from other industries, and household income stimulated by the shrimp industry. A loss or reduction in output by this industry would significantly affect a large number of economic sectors in the Texas economy particularly those in close proximity to the shrimp resource along the Texas Gulf Coast region. Those sectors experiencing the most significant reductions would be: the shrimp industry itself; households; food processing; and petroleum products.

Income and Employment

The amounts of personal income and employment created by the shrimp industry are of importance in evaluating their contribution to the total economic welfare of the State. As indicated in Table 3, about $56.8 million of personal income is created throughout the State's economy by economic activity in the shrimp industry. This income value results both from direct payments to workers in the shrimp industry (estimated to be 37 cents[6] of each dollar of output) and indirect income payments (estimated to total 52 cents[7] per dollar of shrimp output) that are made by other industries as they produce in response to production requirements of the shrimp industry. Since the shrimp industry is relatively labor-intensive, and since it is closely interrelated with other producing sectors of the economy, its impact on personal income is significant. It is estimated that in 1971, the shrimp industry paid a total of $24.0 million directly to households and further stimulated an additional $32.8 million of income payments to households from industries in the remainder of the Texas economy. The income multiplier of the shrimp industry is estimated to be 2.37 ($56.8 ÷ $24.0 = $2.37).

The relationship between employment in the shrimp industry and employment in the total economy is estimated with the use of the shrimp industry employment multiplier. The employment has been estimated at 1.22 (Murrell, Geenens, and McMichael, 1972). This indicates that if production in the shrimp industry is increased enough such that one additional person is employed in the shrimp industry, total employment in the economy will rise by 1.22 persons. The additional 0.22 employees would be employed in industries that respond with increases in output of goods and services utilized in the shrimp industry.

The aggregate employment impact of the shrimp industry in 1971 is estimated from data available on the number of persons employed per dollar of output and the total dollar value of 1971 shrimp output. The most recent information available indicates that just less than one person (0.78) is employed for each $10,000 of output in the Texas shrimp industry (Murrell et al., 1972). Hence, the total value of 1971 output, estimated at $63.9 million means that approximately 5,000 persons were employed directly in the shrimp industry. Moreover, as a result of the multiplier effect, giving rise to secondary and tertiary employment in related industries, it is estimated that the total employment impact on the Texas economy was just over 6,000 employees[8] (4,986 × 1.22 = 6,083).

As with output and income, these employment effects would be concentrated primarily in close proximity to the shrimp resource—the Texas Gulf Coast region. However, some secondary and tertiary impacts of the industry would be distributed throughout all regions of Texas because of the regional interdependence in the state's economy.

[6]From Table 2, Column 2 (23,961 ÷ 63,921 = 0.37).
[7]From Table 3, Column 3 (0.89 − 0.37 = 0.52).

[8]Assuming 100 percent of the employment impact is in the coastal counties, then this is approximately 0.6 percent of the total employment in the coastal counties of Texas.

SUMMARY AND CONCLUSIONS

The Gulf of Mexico is an important resource base for seafood production of which shrimp is the most valuable. The total amount of shrimp landed in Texas in 1971 was 54.2 million pounds with a value of $63.9 million.

In total dollars, the estimated direct, indirect, and induced impact on the Texas economy from the $63.9 million of 1971 shrimp production was estimated at $197.1 million. The contribution to total economic welfare with respect to personal income was $56.8 million and employment created was 6,083 jobs. About 80 percent of this aggregate statewide economic impact is concentrated in the Gulf coast region.

Increased demand by various groups for the resources of the Gulf and bays are causing ever-increasing pressure on local, state, and federal agencies for coastal zone management policies. If such policies are to be sound from the standpoint of the welfare of society as a whole, then economic information as developed in this study must be considered along with information on contributions made by other Gulf Coast resource users. The results of this analysis indicate that the commercial shrimp industry makes an important contribution to the economy of Texas particularly along the coastal region.

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MFR PAPER 1151

Vacuum Cooling and Thawing Fishery Products

JOSEPH H. CARVER

ABSTRACT—A standard pilot plant size retort was modified for purposes of developing empirical information on dehydrocooling fresh fish and vacuum/heat-thawing (VHT) frozen fishery products. Results indicated that effective multipurpose vacuum/heat-processing systems can be constructed from readily available commercial equipment. Dehydrocooling tests indicated that small fish such as whiting can be cooled to 0°C in about 1/2 hour, and VHT tests showed that frozen blocks of headed and gutted (H&G) whiting and shrimp can be thawed in from 1/2 to 1 hour. The described equipment is usable both ashore and at sea. At sea, it is proposed that enough heat energy to power the equipment can be extracted from waste stack gases.

INTRODUCTION

Several years ago, two novel processes were patented for processing fish—one for rapidly cooling and storing cooled fish (Beckmann, 1961) and the other for thawing frozen fish blocks (Bezanson et al., 1973). Though the apparent purposes of these patents appear to be diametrically opposed, the effectiveness of both described processes is dependent on the use of water to transfer heat energy under vacuum conditions.

The first of these two patents is based upon dehydrocooling and was issued to H. Beckmann (1961). Vacuum precooling, or dehydrocooling, is effectively being used today for cooling leafy vegetables. This process takes advantage of the physical penomenon wherein the boiling point of water decreases with a decrease in atmospheric or absolute pressure. At an absolute pressure of 760 mm (14.7 inches) of mercury or normal atmospheric pressure, water will boil at 100°C (212°F); at 4.5 mm (0.18 inch) of mercury, liquid water will boil at 0°C (32°F). According to Beckmann's patent, dressed fish are placed in an airtight container, and when loaded, the air is evacuated from the chamber to promote a rapid evaporation of water from the surface of the fish. Since heat energy is required to change liquid water to gaseous water, the heat necessary to cause this change of state is supplied by the fish; and, thus, the fish loses heat and is cooled. The amount of heat energy given up by evaporation is about 596 calories per kilogram lost water at 0°C or 1,073 British Thermal Units (BTU) per pound of lost water at 32°F[1]. By evacuating the chamber to an absolute pressure of about 4.5 mm of mercury, the fish within can be cooled to 0°C. Once cooled, the fish can then be stored within the chamber at 0°C by maintaining the absolute pressure at about 4.5 mm of mercury. In order to compensate for the loss of water during the cooling and storage stages, the fish are periodically sprinkled with water while under vacuum. This added water can, by dehydrocooling, freeze onto the surface of the fish. Thus, without the use of ice and refrigeration equipment, Beckmann (1961) claims that fish can be adequately cooled and stored in the fresh state. Other advantages claimed are prevention of oxidative rancidity, inactivation of aerobic spoilage bacteria, and the bleeding of the fish is enhanced which results in lighter-colored flesh.

The second patent is concerned with thawing and is known as the Vacuum Heat Thawing (VHT) process. It was specifically designed to factory-thaw large blocks of frozen foodstuffs—i.e., 100 pound (45kg) blocks of frozen dressed fish. The process can be considered to be the opposite of dehydrocooling and thus takes advantage of not only the fact that water will boil or steam condense at a lower temperature under vacuum conditions, but also that the condensation of water imparts heat. This is called the heat of condensation and is the opposite of the heat of vaporization which, again, is considerable. According to the patent, blocks of frozen fish are placed in an airtight container and the chamber is evacuated to a predetermined absolute pressure which will allow for a desired thawing temperature. For example, at an absolute pressure of 17.5 mm of mercury, a temperature of 20°C could be maintained. At the preset pressure, steam is then metered into the chamber and will condense on the surface of the fish giving up its heat of condensation. Under these conditions a kilogram of condensing steam will give up about 585 calories of heat energy (1,053 BTU per pound of steam at 68°F). By careful control of the absolute pressure and steam, it is claimed that the fish can be rapidly thawed without heat damage. Additional advantages claimed are reduction of oxidative changes, inactivation of aerobic spoilage bacteria, and reduction of weight loss due to thaw drip.

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[1]Clarke-Built (Williams), Ltd., Thetford, England. Vacuum-Heat Thawing. Personal communication.

About the time that these inventions were made known, an engineering study (Lange 1946) indicated that with the proper heat exchangers, as much as 770 kg (1,700 pounds) of 0.07 kilogram-force per square millimeter (kgf/mm²) (100 psi)[2] steam could be generated from the heat lost in the exhaust stack of an average New England trawler. This is more than enough energy needed to power a large vacuum unit. It appears then that vacuum systems could be operated aboard the trawlers for only the cost of the proper equipment and its installation.

To the best of our knowledge, these processes are not being commercially utilized by the fishing industry. Possible reasons for this are that there is no firm information available on these vacuum processes, and the apparent costs of the equipment and manpower needed to develop the required information are beyond the means of our hard-pressed fisheries. Thus, because of these reasons and the benefits claimed by the inventors, the Northeast Utilization Research Center undertook work to obtain empirical information on the design and development of a steam-powered pilot plant vacuum processing system and on developing empirical data on the feasibility of dehydrocooling and VHT.

DESCRIPTION OF THE EQUIPMENT

The unit designed and constructed consisted of a two-stage vacuum source, a horizontal food processing retort, and a steam boiler as shown in Figure 1. All components used were readily available and usable both at sea and ashore.

A Kinney Liquid Jet[3] vacuum pump, Model KLJ-120, was chosen as the first stage in the vacuum system. This was because of the availability of water and because this type of vacuum pump is simply a large water aspirator capable of handling large volumes of water vapor as might be expected from VHT and dehydrocooling. In operation, a 10 horsepower centrifugal pump drives water under high pressure through a plate with holes to create a series of jets which cross through an air gap into a venturi tube. As the water crosses the air gap, air and other gases are entrained in the water and are carried through the venturi and expelled. For economy's sake, the water used is recirculated and stored in a tank of about 850 liters (30 cubic feet) capacity. A provision is made to add fresh cool water in the event that the stored water warms. This unit is capable of generating a vacuum equal to that of the vapor pressure of the recirculated water, i.e., about 30 mm (1.2 inches) of mercury absolute pressure at a water temperature of 21°C (69.8°F).

For the second stage vacuum, a steam jet evactor was used. In operation, the steam jet evactor operates on the same principle as a water aspirator except that this pump uses steam as a motive force. Additionally, the steam passing through the jet condenses in the water of the first stage thus helping to generate higher vacuums. The steam jet evactor is dependent upon the first stage in that it does not become efficient unless the absolute pressure at the discharge end of the steam jet is lowered to about 500 mm (19.7 inches) of mercury. With both vacuum sources in full operation, using 0.046 kgf/mm² (65 psi gauge) steam, this system was capable of attaining absolute pressures as low as 0.3 mm (0.012 inches) of mercury. This absolute pressure is equal to the vapor of ice at -29.5°C (-21°F) which was more than adequate for the intended work.

These vacuum sources were connected to the retort using a 101.5 mm inside diameter (ID) (4-inch) pipe. Originally, high density polyethylene pipe was used; however, when steam was allowed to escape through this pipe, the pipe distorted and caused several joints to open and leak thus causing a loss in vacuum efficiency. The plastic pipe was then replaced with iron pipe of the same size to eliminate this problem. Also, a 101.5 mm (4-inch) iron gas cock was installed in the vacuum line for quickly applying or shutting off the vacuum.

The vacuum chamber originally used consisted of a vertical retort of 670 liters (23.6 cubic feet) capacity. A retort appeared to be ideal for the purpose because its heavy walls could withstand the stresses resulting from high vacuum and because it is capable of being sealed. However, the vertical retort was awkward to load, and it was replaced by a smaller horizontal retort whose internal dimensions were 45.6 cm (18 inches) in diameter and 78.7 cm (31 inches) in length. The capacity of this retort was about 128 liters (about 4.56 cubic feet). The only modification made to the retort was to weld in along the top center line a 101.5 mm ID (4-inch) vacuum outlet containing a gate valve for opening or sealing off the vacuum to the retort. This modification in no way affected the usage of the retort for normal steam processing operations. This retort was also equipped with pneumatic controls for steam and air regulation, a steam sparger along its bottom length, and a water inlet.

Steam for VHT and for the steam jet was supplied by a 98,095-watt (10 boiler horsepower) steam boiler. Since the efficiency of the steam jet depends upon

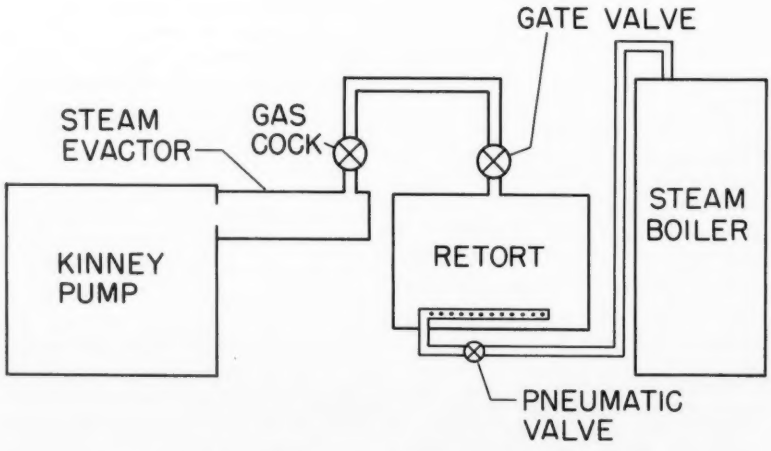

Figure 1.—Pilot plant equipment used for dehydrocooling and vacuum heat thawing tests.

[2]One psi = 7.03×10^{-4} kilogram-force per square millimeter.
[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

the use of dry steam, a steam separator was installed in the steam line as close to the steam jet as possible. This separator removes water condensate from steam and allows only dry steam to pass.

Once constructed, the equipment was tested for leaks and overall efficiency. Leaks were detected by filling the system with a halogenated gas to a little above atmospheric pressure and using an electronic halogen leak detector. All leaks found were sealed with silicone rubber gasket material. Some very small leaks remained as evidenced by a gradual loss of vacuum in the chamber after it was sealed off and evacuated. However, these leaks were too small to affect the outcome of the proposed tests. Subsequent tests indicated that when using only the Kinney pump with 18.3°C (65°F) water, an absolute pressure of 20 mm gauge (0.79 inches) was obtained in 32 seconds. Since the vapor pressure of water at this temperature is 15.8 mm of mercury, the Kinney pump was capable of delivering 99.4 percent of the total vacuum theoretically obtainable or (760 mm − 20 mm/760 mm − 15.8 mm) (100). When using both vacuum systems, an absolute pressure of 4 mm (0.16 inches) of mercury was obtained in 72 seconds. This corresponds to the vapor pressure of water at −1.7°C (28.9°F). When the system was tightly sealed, absolute pressures of about 1 mm of mercury (0.04 inch) were readily attainable. This vacuum would correspond to the vapor pressure of ice at −17°C (1.4°F). Some control over the degree of vacuum was achieved by closing down the gate valve, and thus the temperatures within the chamber could be roughly controlled. Typical evacuation times are shown in Figure 2 when using 0.018 to 0.070 kgf/mm² (25 to 100 psi gauge) steam pressure through the steam jet.

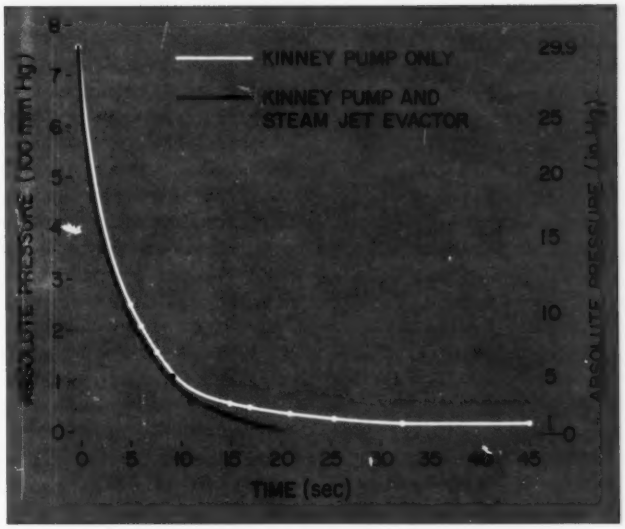

Figure 2.—Typical retort evacuation times illustrating the capability of the equipment to rapidly produce suitable vacuums for dehydrocooling and vacuum heat thawing.

DEHYDROCOOLING

Upon completion of the unit, dehydrocooling and VHT tests were conducted. For the dehydrocooling tests, fresh headed and gutted (H&G) whiting was used since this species is in good supply in this area. The individual weight of the fish used ranged from 100 to 150 grams (0.22-0.33 pound), except in one series where larger, 600-700 grams (1.3-1.5 pounds), H&G whiting were used in an effort to determine the effect of individual size on rates of dehydrocooling. Preliminary work indicated that for best results, the fish needed to be spaced apart from each other, that is, not touching each other, so that the whole surface area of the fish was available for dehydrocooling. Accordingly, fresh wet fish were spaced single layer on an expanded metal screen. In the first three series reported on, the fish were very wet so as to readily drip water; and in the last two series, the fish were wet but not dripping. Thermocouples were inserted into the fish at sites immediately below the surface of the skin and next to the backbone at the thickest portion of the fish. These latter thermocouples were about 13 mm (0.5-inch) deep in the small fish to about 25 mm (1-inch) in the larger fish. This allowed the temperatures of the fish to be continuously recorded at 5-second intervals throughout each test. The fish were then loaded into the retort, the retort closed and quickly evacuated to an absolute pressure of 2-4 mm (0.08-0.16 inch) of mercury. These pressures correspond to the vapor pressures of ice from −9.7°C to −1.6°C (14.5°F to 29.1°F). Since the vacuum system had a tendency to reduce the absolute pressure below 2 mm (0.08 inch) of mercury, attempts were made to regulate the degree of vacuum by closing down the gate valve. Results of the dehydrocooling tests are summarized in Table 1, and a typical dehydrocooling curve is shown in Figure 3.

In the first three series, the surface of the fish cooled to ice temperature in 8 minutes regardless of the size of the individual fish and regardless of the starting temperature. However, as either the

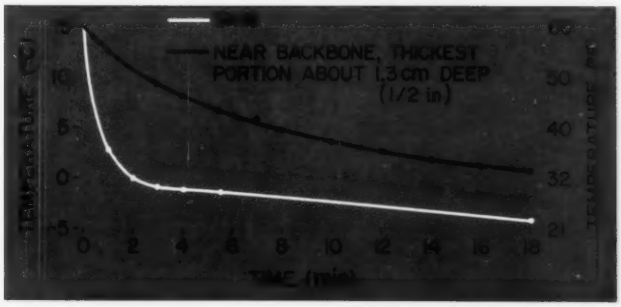

Figure 3.—Typical dehydrocooling curve showing the rapidity of the process and relationship between surface and internal temperatures during dehydrocooling.

Table 1.—Dehydrocooling headed and gutted whiting.

Total sample weight (kg)	Size of fish (g)	Starting temp. (°C)	Time needed to dehydrocool fish to 0°C (min)	
			Surface	Interior
1.5	100-150	21.0	8	15
6.8	100-150	17.0	8	28
8.0	600-700	18.5	8	33
1.0	100-150	21.0	1	14
1.0	100-150	5.0	1	7

total mass of the fish increased from 1.5 to 6.8 kg or as the size of the individual fish increased from 150 to 600 grams, the rate of interior cooling decreased. When the tray was loaded from just a few fish to a maximum number of small fish (6.8 kg), the time to cool the interior of the fish about doubled, i.e., from 15 to 28 minutes. This indicated then that the interior cooling rate is dependent upon the total number of fish, or load, being dehydrocooled. With respect to individual fish size, the interior rate of cooling decreased as the size of the fish increased. Small 100-150 gram fish were cooled to ice temperature along the backbone in 15 minutes, whereas 33 minutes were needed to cool 600-700 gram fish (about twice as thick) to this temperature along the backbone. This is to be expected inasmuch as the heat from the interior of the fish travels by conduction, and fish flesh is a poor conductor of heat.

In the last two series when no excess water was available on the surface of the fish, the surface of these fish cooled to ice temperature in about a minute. The interior temperatures of these fish cooled to 0°C in 7-14 minutes, depending upon the starting temperature. These two series illustrate the rapidity of dehydrocooling at low absolute pressures when no excess water is available. However, these fish tended to become rapidly dehydrated to a point where their appearance was adversely affected. The damage caused by dehydration could not be wholly eliminated by the later addition of water. In the first three series, dehydration was first evidenced by a slow increase in surface temperature. This was probably caused by subsurface heat warming the skin surfaces after most of the water evaporated from the surface of the fish. Further dehydration was averted by spraying the fish with water while under vacuum. For this purpose, a water spray system was built into the retort. This additional water not only prevented surface dehydration, but also aided in further dehydrocooling. Once the fish was cooled, the sprayed-on water froze to form a protective ice glaze over the nonfrozen fish. Thus, it appears that though excess water slows down the dehydrocooling process by increasing the load to be cooled and by adding some heat energy, some excess water is needed to prevent damage by dehydration.

During the dehydrocooling process, it was noted that the ambient temperature within the chamber cooled to about 3°C (37°F) and remained at this temperature even though the fish was at 0°C. The temperature of the retort shell did not change, thus indicating that there was little or no heat being exchanged through the "atmosphere" within the retort. Further, ice-glazed fish were stored in the chilled state for periods of 5-6 hours by maintaining an absolute pressure of 4-6 mm. An examination of the treated fish indicated that some of the ice glaze was lost to evaporation but there were no other adverse effects as a result of dehydrocooling and the short storage period.

These results then indicate that whiting, and probably other fish of similar size, can be rapidly cooled to 0°C by dehydrocooling under conditions that arrest oxidative changes and the outgrowth of spoilage microorganisms. There is an indication that once cooled, the fish can be stored under a vacuum without additional refrigeration. However, since this process depends upon the removal of heat by the vaporization of water, care has to be exercised to prevent dehydration damage to the fish. This can be done by the addition of water during the dehydrocooling and storage periods. The frequency and the amount of additional water would probably be dependent upon the capacity of the system and the degree to which the system is loaded.

VACUUM HEAT THAWING

Vacuum heat thawing tests were conducted on commercially prepared frozen blocks of H&G whiting and shrimp. Initial tests were conducted in the aforementioned vertical retort where larger sized samples could be handled but the process could not be easily controlled. In these tests 4.54-kg (10-pound) blocks of H&G whiting and either 2.27-kg (5-pound) or 4.54-kg (10-pound) blocks of shrimp were loaded onto an expanded metal tray within the retort. Thermocouples were inserted near the center midline and just beneath the outside surface of the blocks for continuous temperature monitoring. The retort was then closed and evacuated to an absolute pressure of about 20 mm. Once the pressure was reached the vacuum line was shut off and steam at 0.06 kgf/mm² (85 psi gauge) was allowed to expand into the chamber until an absolute pressure of about 50 mm (1.95 inches) of mercury was reached. At this pressure, the surface temperature of the blocks rapidly increased to about 38°C (100°F). In order to avoid overheating the samples, the vacuum was reapplied to dehydrocool the surfaces to about 22°C (72°F). Once cooled, the cycle was repeated continuously until the thermocouples along the midline of the blocks indicated that the blocks had reached a temperature of 0°C (32°F) or higher. Thereupon, the retort was opened and the samples checked for degree of thaw. If not

Table 2.—Summary of vacuum heat thawing tests on whiting and shrimp using 0.06 kgf/mm² steam pressure.

Sample	Block size (kg)	Total weight (kg)	Temperature		Total thawing time[1] (min)	Percent thawed
			Initial	Maximum at center line		
Glazed	4.54	18.2	−4.4	0.5	24	60
Whiting Blocks	4.54	18.2	−5.5	2.5	60	100
Glazed	[2]2.27	7.25	−6.1	6.1	1	60
Shrimp	2.27	2.27	−7.2	20.0	8	95
Blocks	4.54	9.1	−9.4	15.5	13	80
	2.27	15.9	−11.1	23.4	51	95
	2.27	9.1	−5.5	15.5	31	90
	2.27	11.1	−3.2	15.0	26	80

[1]Total time of thawing within the chamber.
[2]Loosely packed and lightly glazed.

reasonably thawed, the samples were returned to the retort and the process repeated.

Results of these initial VHT tests are given in Table 2. These results indicate that though the apparent temperature within the block was above 0°C, the blocks were not necessarily thawed. This was because though the blocks appeared to be solid, pockets of air and ice were later found among the fish and shrimp.

In the case of whiting, few enclosed pockets of air or ice were present and it was found that by increasing the temperature to a few degrees above freezing near the center of the block, the fish were thawed to the point where they could be easily separated and filleted. About 1 hour was needed to completely thaw the 4.54-kg (10-pound) blocks of whiting. With respect to shrimp, many pockets of air and ice were present throughout the blocks. The steam apparently was able to enter the air pockets and transfer its heat to the shrimp tissue. Thus, very loosely packed and lightly glazed shrimp blocks became 60 percent thawed when treated to VHT conditions for 1 minute. When the shrimp blocks were tightly packed and more heavily glazed, the VHT time was significantly increased. Under the conditions of these tests, this thaw time varied primarily because the amount of glaze and pockets of ice among the blocks varied. When the temperature of areas along the center line of these shrimp blocks reached 6-10°C, many pockets of ice and frozen shrimp still remained. However, it was noted that when the internal temperature of these shrimp blocks reached 15-23.4°C, the blocks were 80-95 percent thawed without heat damage. The thaw time for these shrimp blocks then ranged from 8 to 51 minutes, depending on the amount of glaze, the size of the blocks, and the size of the load in the chamber. It was also observed that these shrimp would probably thaw faster if some provision was made to remove the thawed shrimp on the surface of the block from the still-frozen shrimp in the interior of the block. As the outside of the blocks thawed, the thawed shrimp tended to form an insulated mat, thus obstructing the flow of heat into the block's interior.

Upon installation of the horizontal retort, more detailed VHT tests were made on H&G whiting. Since the capacity of the horizontal retort was less than that of the vertical retort, smaller sized samples were used throughout these tests. Generally, the procedure for VHT was the same as that previously described except that, as noted, in some tests the pneumatic controls on the steam lines were used to meter steam into the retort during VHT. By careful throttling of the gate valve in vacuum piping and by recalibrating the automatic pneumatic controls, temperatures of 29±1°C (85±1.8°F) could be maintained throughout the VHT test periods. Under these conditions, steam was continuously metered into the chamber.

Table 3.—Summary of vacuum heat thawing tests on whiting using various steam pressures and application of steam.

Sample size (kg)[1]	Steam pressure (kgf/mm²)[3]	Steam application	Initial temperature (°C)	Maximum temperature (°C)	Thaw time (min)
0.45	0.0175	continuous	-17.8	36.7	15
0.45	0.0352	cycled	-17.3	36.7	26
2.27	0.0175	continuous	-17.8	33.9	27
2.27	0.0175	cycled	-17.8	36.7	45
2.27	0.0352	cycled	-15.0	37.8	57
2.27	0.0703	cycled	-12.8	36.7	58
2.27	0.0175	cycled[2]	-7.8	37.3	74
0.227	0.0175	continuous	-7.8	31.1	8-9
0.227	0.0352	pulsed	-17.3	29.4	17

[1]The 0.45-kg sample (1-pound) size consisted of 3-5 H&G whiting frozen together in a block and the 2.27-kg samples (5-pound) consisted of 8-12 H&G whiting frozen in a block. The 0.227-kg sample (0.5-pound) size consisted of 6 or more H&G fish individually frozen and weighing about 0.227 kg (0.5 pound) each.
[2]Full vacuum system used. Absolute pressures of 4.5 mm were used for dehydrocooling.
[3]One psi=7.03 × 10^{-4} kgf/mm².

Results of these tests are given in Table 3. It is evident from these results that VHT can be accomplished much faster by a continuous application of steam than by a cycled application. This is because with the latter, the surfaces of the products heat up much faster with a full flow of steam causing a need to remove excess heat by dehydrocooling, an extra step in the procedure. Thus, with a continuous flow of steam to maintain a temperature about 36°C (97°F), the thawing times were nearly halved, i.e., 8 to 27 minutes for 0.227- to 2.27-kg samples with a continuous flow of steam as compared with 17 to 45 minutes for similar size samples using cycled steam. These data also indicate that VHT was faster with lower steam pressures than with higher steam pressures, i.e., for a sample size of 2.27 kg, 45 minutes were needed to thaw the fish when using 0.0175 kgf/mm² (25 psi gauge), as compared to 58 minutes when using 0.0703 kgf/mm² (100 psi gauge) steam. This was because when using higher pressure steam the pressure was more difficult to control, the tendency for overheating increased, and there was a need for longer dehydrocooling time. The greater efficiency of the lower steam pressures also tends to indicate that the major source of heat energy for thawing came from the heat of condensation. Lastly, when dehydrocooling with an absolute pressure of 4.5 mm (0.018 inches) of mercury, excessive cooling of the surface of the samples occurred, thus increasing the time needed to thaw the samples. For example, when using the full vacuum system for dehydrocooling at an absolute pressure of 4.5 mm (0.018 inches) of mercury between cycles of steam injection, 74 minutes were needed to VHT a 2.27-kg sample when using 0.0175 kgf/mm² steam. Under the same conditions, except that an absolute pressure of 18 mm (0.71 inches) was used, the samples were thawed in 45 minutes.

With respect to VHT whiting at a maximum temperature without causing physical damage to the fish, it was found that the skin of the fish began to cook when exposed to temperatures of 43-46°C (110-115°F) for a few seconds. When this happened, the skin became gummy and began to slough off from the flesh below. This was also true for other thin-skinned species such as herring. Exploratory VHT tests indicated that higher maximum thawing temperatures such as 55°C (130°F) could be used on other species, such as cod and ocean perch, without causing physical damage. These latter species have thicker skins which apparently offer greater

protection from the rigors of the process.

It is doubtful that this process could be used to temper fishery products, i.e., to raise the temperature of a frozen product, without thawing, in order to achieve a degree of hardness suitable for easy cutting with a saw. However, where there is a need to thaw the product prior to further processing, the data show that the process is rapid and effective. For example, experience within the laboratory indicates that 24-48 hours were needed to thaw 2.27- to 4.54-kg (5- to 10-pound) blocks of fish or shrimp in air at 2-4°C (35.6-39.2°F) and about 1-3 hours in 18.3°C (65°F) water. By the VHT process, these products can be thawed in as little as 10 minutes to 1 hour, depending upon the capacity of the equipment, the size of the load, steam pressures, the application of steam, and the presence of extra water or glaze. It should be pointed out here that by the use of microwaves[4] some hard-frozen products can be very rapidly tempered or thawed, depending upon need. For example, 50 pounds of hard-frozen shrimp were thawed per hour per kilowatt energy to the point where they could be separated and further processed.

CONCLUSIONS

These exploratory studies have shown that vacuum processes could be applied for dehydrocooling and for VHT fishery products. The components needed are simple in design and operation. Moreover, an engineering study has indicated that enough energy can be recovered from waste stack heat to power the needed equipment. Thus, the equipment could be designed for use at sea as well as ashore where power is readily available.

Good results were obtained in dehydrocooling of small fish such as H&G whiting and herring. The exterior of these fish cooled rapidly, that is, from ambient to freezing temperatures in only 8 minutes. One-half hour was needed to cool to 0°C (32°F) all the interior portions of fish of about 50 mm (2 inches) at their thickest point. However, in order to rapidly cool, it was necessary to expose the whole surface of the fish to the vacuum. This indicates fish cannot be rapidly cooled by the dehydrocooling process unless these fish are spaced apart, i.e., in layers one fish deep rather than in large masses as is now the practice. The larger the fish, the more important would be the need to separate the fish in order that the heat from the interior portions can be removed. Because the cooling process depends upon the evaporation of water, there is a danger of overly drying the surface of the fish. The danger can be readily avoided by sprinkling the surface of the fish with water while under a vacuum, and again, this is best done on layered fish. The additional water by its evaporation aids in the overall cooling effect. Once cooled, the added water that has not evaporated will freeze over the surface of the fish to form a protective ice glaze. If judiciously done, this glaze can be formed over nonfrozen fish inasmuch as the freezing point of fish flesh is about −2°C (28°F). There is no further need to keep the cooled fish spaced apart so that the fish can be stored in a massed form. If stored under a maintained absolute pressure of about 4.5 mm of mercury in an airtight container, the fish will remain cool. Only a periodic addition of water would be needed to replace that water lost by continuing evaporation. This container, if properly constructed, could also serve as a shipping container, thus also aiding in the transport of the fish.

Good results were obtained in VHT blocks of H&G whiting and shrimp. Normally 1-2 days are needed to refrigerator-thaw these products. Several hours are needed for thawing in 18°C (65°F) water. Bacterial degradation can occur during these thaw times and especially in the case of water-thawing, the bacterial contamination can be rapidly spread by the water. With VHT, these products can be completely thawed within 1 hour in a manner that does not promote the spread of bacterial contamination. The thaw times given could probably be reduced in some instances where the product is cooked during later reprocessing. For example, since some breaded shrimp are partially cooked prior to refreezing and sale, shrimp blocks for this purpose could be VHT at higher temperatures and shorter periods of time. Any cooking damages that might occur would probably be of no consequence in cooked breaded shrimp. It should be pointed out here that much has been done in developing the technology on the use of microwave energy for thawing and/or tempering frozen seafoods for further processing. For example, with one microwave unit hard-frozen shrimp were continuously thawed for further processing at the rate of about 22.7 kg (50 pounds) per hour per kilowatt energy. Where the microwave process is a continuous process, VHT is a batch-type process. Thus, to a processor who has need of rapidly thawing fishery products, VHT appears to be an attractive potential process.

Though no bacteriological work was done under the conditions of dehydrocooling and VHT, it is quite conceivable that at least during the time these processes are being applied, bacterial degradation is arrested. It is believed that most of the bacteria on fishery products are aerobic, i.e., they need air to grow and function. By the very nature of these processes, nearly all the air that sustains these bacteria is removed and thus they would cease to function.

It should be noted here that the basic equipment used for VHT is the same as that used for dehydrocooling. Thus the equipment is quite versatile since it can be used for VHT, dehydrocooling, retorting cans of food, and as a pressure cooker for such products as crabs. There are indications that this basic equipment can be used for other purposes. Some suggested uses are to briefly treat the surfaces of fishery products with high temperature steam in an effort to destroy surface spoilage bacteria. It is believed that most of these bacteria live on the surface of the fish and most are psychrophiles or cold-loving. It is further believed that these bacteria can be easily destroyed by mild heat. Another suggested use is to destroy surface bacteria by the use of sterilant gases.

Lastly, these results also indicate that these processes probably can be used for processing other foodstuffs. Since fresh fish can be dehydrocooled, other flesh foodstuffs could probably be

[4]Moore, F. E., P.O. Box 196, Rye Beach, N.H. Personal communication.

rapidly cooled. The criteria here would be that the foodstuff be wet and offer a large surface area with relation to product weight. For example, freshly defeathered and eviscerated chicken could probably be cooled quite rapidly both inside and out by this process. Moreover, the process would promote bleeding, an added benefit. With respect to VHT, this process might be of some benefit to those industries that reprocess frozen foods. An example of this would be the meat industry where meat is frozen for later processing into hamburger. As with fish, the frozen meat could probably be effectively VHT in a rapid manner which would tend to maintain the quality of the meat.

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MFR PAPER 1152

An Empirical Study of Limited Entry in Alaska's Salmon Fisheries

JAMES E. OWERS

INTRODUCTION

As one of the few remaining natural resources to have virtually free access, the fisheries have recently received considerable attention from social scientists. A general theory developed by economists argues that without limits on access, the fisheries will employ more inputs of labor and capital than necessary to harvest the resource (Crutchfield and Pontecorvo, 1969). It is argued that this results in a loss to the economy both because of incorrect factor allocation and because the potential economic rent derived from the fisheries could accrue to the custodians of the resource. Accordingly, the solution to the problem is to reduce the inputs of labor and capital to a point where the marginal cost of an additional unit of fishing effort just equals the revenue it produces.

More recently, several economists, sociologists, and others have questioned the wisdom of restricting access to the fisheries. Their concern is that the social upheaval caused by displacing persons with little employment opportunity outside the fisheries may not justify the gains to be derived by increased economic efficiency (Bishop, 1973; Huq, 1971).

Empirical evidence collected by the State of Alaska both before and after passing limited entry legislation in 1973 strongly suggests that, first, limited entry or controlled access is necessary for reasons other than those suggested by a narrow concept of economic efficiency, and second, rather than causing social upheaval, limited entry can alleviate social distress if applied wisely.

It is suggested that the evidence collected in Alaska's salmon fisheries may characterize many high value coastal fisheries of the United States.

EARNINGS OF SALMON VESSELS

In economic theory a factor of production will not be employed in the production of a certain commodity unless the remuneration it receives at least equals the compensation that could be earned in alternative employment. According to this theory, capital and labor will stop entering a fishery once every factor of production is employed at an "opportunity" wage.

Evidence shows that this is not the case in Alaska's salmon fisheries. During the spring of 1974, Alaska's Commercial Fisheries Entry Commission

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Alaska salmon management areas.

Table 1.—Analysis from landing records and interviews with active commercial fishermen for the years 1969-73.

Area	5-year average gross earnings	Deflated 1973 operating costs, fixed costs, and depreciation[1]	Labor costs[1]	Net earnings
Southeastern purse seine	$28,380	$7,485	$11,825	$9,070
Southeastern drift gill net	10,365	3,189	1,712	5,464
Power troll[2]	5,689	3,259	1,934	496
Prince William Sound drift gill net	5,777	3,230	1,642	905
Prince William Sound purse seine[3]	18,037	3,196	8,116	6,725
Cook Inlet drift gill net	4,430	1,998	1,004	1,428
Cook Inlet set gill net	2,854	2,109	1,227	- 482
Kodiak purse seine	15,569	3,498	6,869	5,202
Bristol Bay drift gill net	7,309	1,367	2,777	3,165
Bristol Bay set gill net	2,080	735	458	887

[1]For vessels participating in several fisheries costs have been prorated. Operating costs such as fuel and food are prorated on the basis of time fished. Fixed costs, such as insurance, have been prorated on the basis of gross earnings. Crew shares and certain repairs have been derived for the specific fishery examined.
[2]1973 data only.
[3]Not open in 1972.

analyzed computerized landing records collected by the Alaska Department of Fish and Game for the years 1969-73 and conducted field interviews of 520 active commercial fishermen (Owers, 1974). Table 1 summarizes the results for the more important salmon fisheries in the state. Each fishery is a relatively homogeneous unit since a fisherman must buy a gear license for a specific type of gear in one area only, although there are a number of fishermen who fish multiple gear types. Earnings fluctuate widely, depending upon the size of the salmon runs and prices paid; therefore, gross earnings have been averaged over the 5-year period. In deriving costs of operation, all costs have been prorated to each specific fishery based on time fished and percentage of gross earnings received. Costs, which were collected by interview for 1973 only, have been extrapolated over the 5-year period and deflated by the Consumer Price Index. Labor costs are for crew members only. "Net Earnings" includes a return to the operator's labor, management, and investment.

As can be seen, the level of net earnings is very low in many of the fisheries. When one considers prevailing rates of interest, many operators would have made more money by selling their vessels and gear, investing the proceeds, and living on interest payments or dividends. The remuneration for their labor in these fisheries, in other words, was actually less than zero. Wages in industries which could logically be considered alternatives to commercial fishing in Alaska provided far higher incomes. For example, in 1973 the average wage earner in the contract construction industry earned $8,175, and those in the timber industry earned $6,490 in the months from May through September, the period which roughly coincides with the salmon fisheries.

PROFESSIONALISM IN THE SALMON FISHERIES

Low fishing earnings suggest that for many individuals commercial fishing is not their main source of income. Licensing and other data collected by the State of Alaska support this conclusion and further indicate that there are fundamental differences between vocational fishermen and others in the harvesting segment of the industry.

Table 2 shows the turnover in licensing that occurred in the salmon fisheries between the years 1969 and 1972. The data includes only those people who actually fished since approximately 10-20 percent of the licenses sold in the State each year are never used.

It is apparent that there is a very large turnover in licenses from year to year. With the exception of the Southeastern (Alaska) purse seine fishery, over half of the fishermen fished only 2 years between 1969 and 1972, and one-third fished only 1 year. Some license turnover can be explained by the fact that individuals may shift from one type of gear or area to another, depending on run forecasts or other reasons; nevertheless, it remains true that most are caused by individuals actually leaving or entering the fisheries. Based on this data, it is fair to assume that a large segment of Alaska's salmon fishermen have relatively high labor mobility.

Besides a rapid turnover in licenses, data show that within a given fishing season many fishermen participate only a short time. Table 3 shows the percentage distribution by fishery for the total number of vessels which fished in 1972. Many of the fisheries in the State last only a few months, yet there were still a large number of fishermen who fished half or less of the total fishing time available, usually at the peak of the salmon runs. Many of these individuals fish only during vacations or on weekends.

As part of a study of fishermen's incomes, the Internal Revenue Service (IRS) agreed to study tax returns submitted by 20 percent of the individuals who fished in Alaska, including nonresidents, in 1971 and 1972. Since IRS data is confidential, the survey was designed in such a way that individual identities were not revealed to the Commission. The survey compared nonfishing occupational income, or in other words, earned income received from employment outside of fishing (investments, pensions, transfer payments, etc. were not included) with gross earnings received from fishing. The actual formula

Table 2.—License turnover. Percent of total that fished any time between 1969-1972, by fishery.

Area	Fished 1 year only	Fished 2 years	Fished 3 years	Fished all 4 years
Southeastern purse seine	25	17	18	41
Southeastern drift gill net	44	15	14	27
Power troll	45	22	20	13
Prince William Sound purse seine[1]	34	20	46	—
Prince William Sound drift gill net	36	17	14	32
Cook Inlet drift gill net	42	23	15	20
Cook Inlet set gill net	46	28	18	8
Kodiak purse seine	41	16	13	30
Bristol Bay drift gill net	34	18	16	31
Bristol Bay set gill net	52	27	12	8

[1]Was only open 3 years (not open in 1972).

Table 3.—Active participation—1972. Percent of total number of vessels that participated, by fishery.

Area	3 weeks or less	4-6 weeks	7-9 weeks	10-12 weeks	13 weeks or more
Southeastern purse seine	3	4	46	42	4
Southeastern drift gill net	9	10	14	20	47
Power troll[1]	—	—	—	—	—
Prince William Sound purse seine[2]	9	69	22	—	—
Prince William Sound drift gill net	18	18	21	34	9
Cook Inlet drift gill net	32	63	5	—	—
Cook Inlet set gill net	32	19	34	12	3
Kodiak purse seine	21	55	23	1	—
Bristol Bay drift gill net	44	40	12	3	—
Bristol Bay set gill net	59	37	3	—	—

[1]Data not yet available.
[2]Data for 1971.

Table 4.—Income dependence—1972. Comparison between fishermen with different length history of participation.

	Fished 1 year only	Fished 3 or more years
	Percent	
Southeastern purse seine	75.0	90.5
Southeastern drift gill net	59.0	88.6
Power troll	50.5	75.5
Prince William Sound purse seine[1]	—	—
Prince William Sound drift gill net	59.0	77.4
Cook Inlet drift gill net	54.4	58.9
Cook Inlet set gill net	30.4	46.2
Kodiak purse seine	60.6	73.8
Bristol Bay drift gill net	30.3	33.6
Bristol Bay set gill net	32.9	62.8

[1]Not open in 1972.

used was gross earnings received from the fishery being studied, divided by the sum of gross earnings and nonfishing occupational income. The results were multiplied by 100 to derive an "Income Dependence Percentage" and stratified by the length of time individuals had fished.

One would suspect that fishermen who have fished several years are more economically dependent on commercial fishing than those who have fished only a short period of time. As Table 4 confirms in all cases, those who fished 1 year showed less dependence upon commercial fishing than those who fished 3 years or more. The actual magnitude of the difference would have been greater had net earnings from fishing been used instead of gross earnings. Those fisheries which have high average gross earnings tend to push all figures toward the high end of the scale.

Not shown, but also of interest, is the distribution of gross earnings in the fisheries. Rather than a bell shaped distribution or one skewed to the left (indicating a high concentration of dependent fishermen with a steady decline into levels of less dependence), the distribution in many fisheries is a U-shaped curve with concentrations of individuals at both ends of the scale. This indicates that fishermen tend to be either dependent upon commercial fishing or else not dependent at all.

IMPLICATIONS FOR LIMITED ENTRY

It is obvious that as more fishermen attempt to harvest a fixed level of total catch, the share to each individual fisherman is reduced in proportion to the number who participate. Not so obvious, however, as the empirical data suggests, is the fact that there is no self-regulating mechanism limiting the number of fishermen at a level that will provide an adequate income as long as a large segment of the industry is highly mobile or has little economic dependence upon commercial fishing. In these circumstances uncontrolled entry virtually guarantees impoverishment for many vocational fishermen who live in remote areas or who through age, lack of training, or other reasons exhibit low labor mobility. Any increase in their earnings is quickly dissipated by new entrants.

The scheme chosen for controlling entry should be closely tailored to the needs of the fishery. Among the means suggested for limited entry have been direct control of licenses, taxes or fees to discourage entry, and direct quotas on individual fishermen (Christy, 1974). A system of taxation or fees would in effect force vocational fishermen to pay the cost of eliminating nondependent fishermen. Since low earnings do not seem to discourage new entrants, a tax or fee would probably have to be quite high in order to be an effective deterrent to entry and could be beyond the ability of many vocational fishermen to pay. The feasibility of administering a quota system on individual fishermen when dealing with a highly cyclic resource with thousands of participants is virtually impossible.

The data presented here strongly suggest that a program to control licenses is the most effective method for limiting entrants to Alaska's salmon fisheries and, in fact, is the method that is being used by the State. In contrast to a system of taxes or fees, under a licensing system, the initial issuance of licenses can favor vocational fishermen using objective, standardized criteria. A licensing system also insures that the immediate benefits of a limited entry program pass on to the fishermen. Low earnings in Alaska's salmon fisheries make this an urgent consideration.

EFFECT OF LICENSE LIMITATION ON INCOMES

Evidence that a scheme to control licenses will increase incomes to participants comes from two sources. In British Columbia, where a license limitation program has been in effect since 1968, average gross earnings to fishermen have more than tripled (Campbell, 1974). In part, this is caused by a rapid rise in fish prices and good salmon runs; however, there is little question that without limited entry, increased earnings would have been quickly dissipated by new participants. In Alaska, for example, sales of commercial gear licenses are very closely related to the projected size of the salmon runs (Anonymous, 1973).

Earnings in Alaska's salmon fisheries which have not deteriorated are in those fisheries which have maintained stable

levels of gear. This has occurred in salmon fisheries, which require relatively large investments in order to compete successfully. In effect, large investments discourage new participants and have acted as barriers to entry.

CONCLUSIONS

The empirical evidence gathered in an analysis of Alaska's salmon fisheries indicates that fishermen's earnings are, in many cases, below opportunity incomes. Furthermore, there is no self-correcting mechanism for assuring adequate incomes as long as a large percentage of fishermen have little economic dependence upon commercial fishing.

The data indicate that there are sufficient differences between vocational and others in the fisheries that a method of controlling licenses into Alaska's salmon fisheries can be based upon objective, standardized criteria designed to favor those most economically dependent on commercial fishing. Stabilizing or reducing the level of gear in the fisheries will result in increased incomes to vocational fishermen.

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MFR PAPER 1153

High quality salmon fry can be produced at a reasonable cost.

A New Incubator for Salmonids Designed by Alaska Laboratory

FREDERICK H. SALTER

ABSTRACT—After several years of experimentation, Auke Bay biologists and the research design and devices fabricator have built a salmonid incubator that has the capability to produce high quality fry at a reasonable cost. The system is easy to modify for experimental work and is constructed from materials that facilitate use in the field.

INTRODUCTION

For over a century large-scale production of salmonid fry in hatcheries has been done in essentially the same manner. It has become increasingly apparent that egg-to-fry survival has been much better in hatcheries than in nature, but the quality of the hatchery fry has often been poor. The low quality may not be significant in species that are kept in the hatchery for a few months after emergence as fry—chinook salmon (*Onchorhynchus tshawytscha*) and coho salmon (*O. kisutch*). It may be a critical factor, however, in species that are released to the wild when the fry emerge from the spawning bed—pink salmon (*O. gorbuscha*) and chum salmon (*O. keta*).

Another problem has been the prohibitive cost of many hatchery systems. Some systems are so costly to build and maintain that even though they produce strong healthy fry, they are not feasible.

Personnel at the Auke Bay Laboratory have worked to find or develop an incubation system that produces high quality fry at a more reasonable cost than traditional hatchery methods. Among the popular traditional incubators tested here were the Heath and Bams models. Neither of these satisfied both quality and cost criteria. The Heath incubator produced large numbers of fry in a small area and required comparatively little water, but it did not significantly improve the quality of the fry. Although the Bams rugose substrate and water filtration system yielded high quality fry, it required expensive manpower and a great deal of water.

So the people at Auke Bay began to develop new incubator systems. The design presented here is the culmination of many years of experimentation. I believe that it will satisfy both quality and cost conditions. It is the result of a trial-and-error process, and would not have been possible without the work of people like Chester R. Mattson, Robert Dewey, Sidney G. Taylor, Jack Bailey, William Heard, and William McNeil (Mattson, 1968[1]; McNeil, 1970 and 1974; Bailey and Heard, 1973; Dewey, 1974[2] and Bailey and Taylor, 1974a and 1974b).

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[1]Mattson, C. R. 1968. Early Sea Life of Salmon, Pink Salmon Investigations, Quarterly Progress Report, 1 Jan.-31 Mar. 1968. On file at Auke Bay Laboratory, National Marine Fisheries Service, Auke Bay, AK 99821.

[2]Dewey, R. D. 1974. Red salmon aquaculture studies, Anadromous Fishes Investigations, Progress Report, 1 July-31 Dec. 1973. On file at Auke Bay Laboratory, National Marine Fisheries Service, Auke Bay, AK 99821.

In 1967 Mattson experimented with an incubator featuring mesh trays that allowed fry to fall through as soon as they hatched. Dewey designed the first AstroTurf[3] substrate incubator during the winter of 1973-74. Later that same year Taylor and Bailey used the AstroTurf in an upwelling-type incubator.

The present Auke Bay incubator was started early in 1974. I was making improvements on an AstroTurf incubator for Bailey at the Auke Creek Hatchery, when Heard, Project Supervisor at the Little Port Walter Field Station, requested a Heath type incubator with an AstroTurf substrate that could be altered to allow voluntary escapement of fry. We decided to go ahead and design one incubator that would incorporate all the features Heard and Bailey were looking for. By combining Mattson's mesh fry trays and Dewey's AstroTurf substrate with Bailey's and McNeil's information on oxygen requirements, egg density data, and flow rates, I came up with the present design.

CONSTRUCTION AND OPERATION OF THE NEW AUKE BAY INCUBATOR

The basic incubator unit consists of two sections—an insert section and a housing section. The insert section is nested in the housing section. The incubators can be operated in stacks or singly. When stacked, the extended lower sides of the housing section hold the insert section in place. Each stack has a base section and a cover section (Figs. 1 and 2).

Every section contains two removable egg trays which can be inserted or removed during incubator operation. While the incubator is operating, water is directed into the cover section. The water flows down into the head chamber of the housing section below and gravity carries it through the lower units.

Water enters the housing section head chamber and flows under the baffle. Some of the water then flows horizontally through the rugose substrate (AstroTurf), and some upwells through the egg trays and flows horizontally over the eggs. All the water passes

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

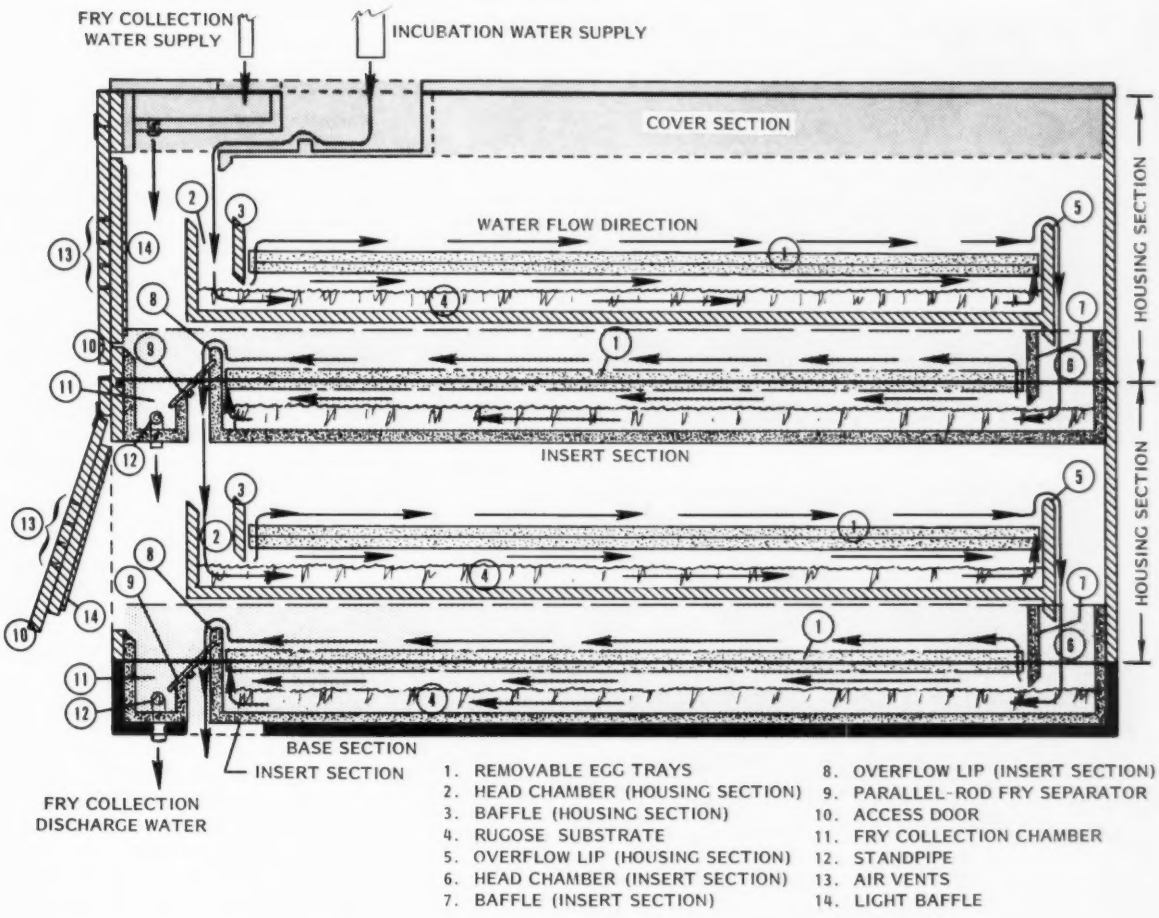

Figure 1.—Cross section of the incubator developed by the Auke Bay Laboratory.

in a thin sheet over the overflow lip and drops down to the head chamber of the next insert section. The water goes under the insert section baffle and proceeds as described above. The water spills over the overflow lip of the insert section and is discharged to the head chamber of the housing section below.

The incubators should be inspected periodically with a long-stem dental mirror to see when the eggs have hatched and the alevins have fallen through the plastic mesh of the egg trays to the substrate below. If desired, the parallel-rod fry separator can be inserted behind the overflow lip at an angle at this time. This will prevent any early alevin migration. After the alevins have fallen through the tray, the access door is opened and the egg trays are removed from the incubator by pulling a pair of cords attached to the sides of the tray. After the egg tray is removed from the incubator, the parallel-rod fry separator can be reinserted behind the overflow lip if early migration is still a problem.

The parallel-rod fry separator is inserted into the downstream face of the overflow lip just before the fry are expected to migrate. The fry separator allows the migrating fry to enter a fry collector rather than the lower sections of the incubator. Most of the water passing the overflow lip falls through the parallel rods into the lower head chamber and fry slide down the rods into the fry collector. When the fry separator is placed in the unit, a small stream of water starts flowing into the fry collector water intake of the stack cover section. This water falls down into the uppermost fry collector chamber and builds up to the top of the standpipe and then overflows to the fry collector of the next lower section. The water in the fry collector cushions the fry's fall off the parallel-rod fry separator. The emerging fry in each stack of incubators accumulate in the lowest section and are collected in the front of the stack of incubators. If desired, the fry from an individual tray can be collected by installing suitable plumbing.

The incubators can also be placed individually on vertical racks or shelves and operated just as if they were stacked. This will allow removal of any unit while lower units receive water from the unit above.

The overall size of the original Auke Bay incubator is approximately 48 inches long, 18 inches wide, and 13 inches

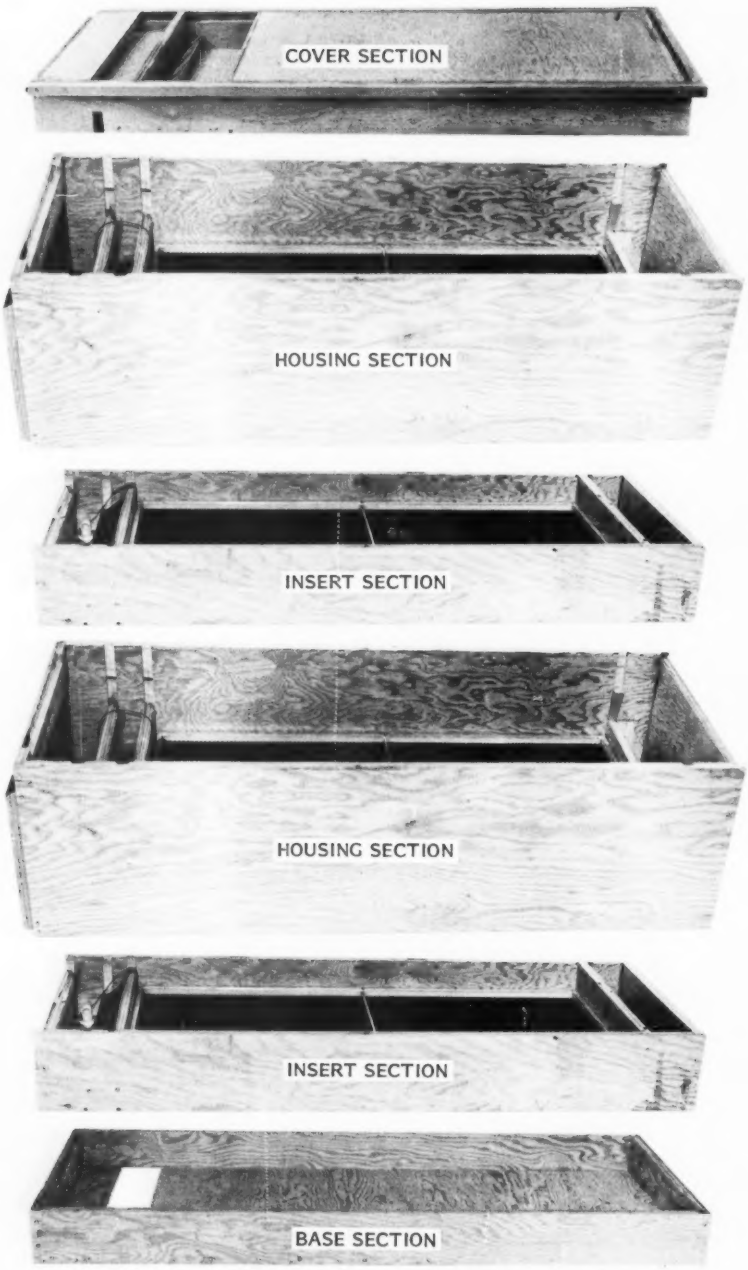

Figure 2.—Photograph of two incubator units with a base section and a cover section.

high. These dimensions were selected for efficient use of 4- × 8-foot sheets of plywood, but the exact dimensions are not critical. The units can be made longer but will still require only a narrow space between the faces of the stacks because the egg trays can be made in short sections instead of long ones and can be hooked together to fill the length of the incubator sections. As the trays are pulled out through the access door, they can be unhooked.

Removing trays of unhatched eggs without disturbing the fry, admitting light, or moving the incubators reduces the tendency for premature emergence, cuts down on fungus growth, and reduces the amount of oxygen needed. If alevins are prematurely flushed out of one tray, they will have multiple opportunities to settle out in a lower unit. The egg trays are made with a frame of aluminum channel and covered with plastic mesh held in place with appropriately sized strips of sheet polyethylene.

Stacking the Auke Bay incubator makes more efficient use of hatchery floor space. Each incubator can be modified to handle more than one layer of trays if higher densities of eggs are needed. The incubator can also be modified for experimental work that requires fry separators for each tray of eggs by replacing the insert section of each unit with a shallow trough with egg trays to return the water to the front.

SPECIAL FEATURES OF THE AUKE BAY INCUBATOR

1. Migration of fry can be voluntary or controlled.
2. Water is used very efficiently.
3. Gas exchange occurs as the water flows and falls into the lower head chamber in a thin sheet. This exchange renews dissolved oxygen and eliminates some of the dissolved ammonia metabolic wastes.
4. Flow is horizontal through the substrate; this can be changed to upwelling by placing the substrate on a perforated false bottom about one-half inch above the bottom of the tray.
5. Egg trays can be easily removed from the front. Water intake for operation is at the front on the top. Water discharge and fry immersion is from the front on the bottom.
6. All light is sealed out in normal operation.
7. The incubators can be stacked with or without a rack.
8. When incubators are stacked, all sides are straight from top to bottom, facilitating insulation where freezing is a problem.
9. Fry can be raised on rugose substrate of various materials such as gravel or AstroTurf.
10. The units are small and lightweight and can be transported by plane to remote areas.

11. The incubator does not require attention after initial loading.

12. The total unit can be made from plywood with a table saw. For mass production, the design will permit use of molded plastics.

13. The incubator has no screens that might become plugged up with algae or sediment. The parallel-rod fry separator is required only under certain conditions and can be removed and cleaned without disrupting the system.

14. The units make efficient use of the hatchery space from floor to ceiling. They can be placed with their backs to a wall and put in stacks side by side.

15. The incubator can be easily modified for research use by dividing the trays and the fry-collecting chamber across the overflow lip.

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NOAA Raises Coastal Zone Management Status

A new post reflecting the National Oceanic and Atmospheric Administration's increased involvement in the orderly management of the coastal environment has been created by NOAA Administrator, Robert M. White. Robert W. Knecht, Director of the Commerce Department agency's Office of Coastal Zone Management, will serve in the new position of Assistant Administrator for Coastal Zone Management.

In announcing the appointment, White said: "The elevation of the coastal zone management program to the Assistant Administrator level reflects the fact that the program has come of age. There is a greatly increasing awareness of the need for protecting and making more rational use of the coastal resources of the nation, as well as in developing methods for managing those resources."

White added that "the recent emergence of a wide range of energy problems has focused attention on the coastal zone for deepwater ports, floating nuclear power plants, and offshore oil and gas drilling and has served to draw attention to the program and to the urgent need for closer cooperation between state and federal governments."

OCZM, as a part of NOAA, is charged with coordinating with states in their development of a program for managing the coastal zone. In addition to providing grants for program development and implementation under terms of the Coastal Zone Management Act of 1972, OCZM gives technical assistance to states, and is helping them prepare for increased pressures to develop the shore, conflicting uses of the coastal zone, as well as for the onshore impact of oil and gas exploration and related issues. OCZM has also attempted to assure that state concerns are reflected in the plans of federal agencies involved in activities along the coasts.

Before assuming his present position, Knecht was Deputy Director of NOAA's Environmental Research Laboratories in Boulder, Colo. He first joined the government in 1948 with the National Bureau of Standards and has held a series of successively more responsible positions. In 1967, he was awarded a Department of Commerce gold medal for leadership in a satellite experiment and has received several other awards for community service.

A graduate of Union College, Schenectady, N.Y., Knecht was a Fellow at Cambridge University (England) in 1959-60, and in 1971, on leave from NOAA, earned a Master of Marine Affairs degree at the University of Rhode Island. A native of Ogdensburg, N.Y., he served in the U.S. Navy, and is a former mayor and vice-mayor of Boulder. He has written 35 technical papers on solar-terrestrial relations, atmospheric and space physics, and coastal zone and land management use.

Future of Red Crabs Rests with Consumer

Shoppers may soon notice a new seafood delicacy, the deep-sea red crab, showing up alongside its cousin, the king crab, in the frozen food sections of local supermarkets if there is a market for it. So says Sea Grant scientist Andreas Holmsen of the University of Rhode Island's College of Resource Development, and Hiram McAllister, a shellfish consultant from the State of Washington, who recently concluded an economic and technological study of the red crab fishery supported by the National Oceanic and Atmospheric Administration. One of the Commerce Department agency's functions is to study the feasibility of harvesting and marketing underutilized species of fin- and shellfish.

Holmsen estimates that the fishery could support a maximum of seven to eight vessels supplying three processing plants, with a total output of around 1.2 million pounds of meat per year. However, he says that current large inventories of king crab, the major competitor of the deep-sea red crab, and declining consumer buying power, make the future for the red crab market unclear. "The problem is primarily economic rather than technological," he says. "If the fishermen can't get a high enough price at the dock for their catch, they'll be tempted to return to offshore lobstering or trawling. And if the processors feel they have to pay so much that they can't compete with products like king crab, they aren't going to build a new plant in the first place."

The red crab is a bottom feeder that prefers the cold waters off the continental shelf from Maine to Cape Hatteras at depths up to about 2,500 feet. The National Marine Fisheries Service, another branch of NOAA, estimates it is there in substantial numbers—at least five million pounds a year can be taken without damaging the stock—and the technology exists for harvesting and processing the crustacean, but as yet there is no large market for it.

The landing price for red crab last year was 30 cents per pound until a slump in the market in the fall. Groundbreaking for the first full-scale commercial red crab processing plant took place in New Bedford, Mass., last September and several fishermen have supplied a pilot plant in Point Judith, R.I., with red crab catches over the past year at prices they considered favorable.

Red crabs average about one and one-half to two pounds at maturity, of which about 25 percent is recovered and marketed as meat. Whole, frozen crabs and cocktail fingers (claws) also have been marketed.

Holmsen's study at the University of Rhode Island complements the efforts of the National Marine Fisheries Service. NMFS, through its New England Fisheries Development Program on latent and underutilized species, considers the red crab one of its target species.

A report on the study by the Sea Grant researchers examines not only the economic aspects of red crab harvesting and processing but also provides detailed specifications on the construction of crab pots, the equipment and layout necessary for a processing plant, and the types of vessels that the authors feel are most suitable for industry. Entitled "Technological and Economic Aspects of Red Crab Harvesting and Processing," the report is available from the Marine Advisory Service, University of Rhode Island, Narragansett, RI 02882.

NOAA Issues New Shellfish Poster

The sixth in a series of Commerce Department posters depicting marine life in coastal waters has been issued by the National Oceanic and Atmospheric Administration.

The four-color poster, Mollusks and Crustaceans of the Coastal U.S., displays 60 species of shellfish that are or have been important to food and recreational fisheries of the United States. The poster is keyed to indicate those shellfish found on the Pacific Coast and in the Atlantic and Gulf areas.

Jack W. Gehringer, Deputy Director of NOAA's National Marine Fisheries Service, made the initial presentation to Congressman Gerry E. Studds of Massachusetts, and to Everett A. Tolley, Executive Director of the Shellfish Institute of North America during Fish Expo '74 held in Norfolk, Va.

Developed by Bob E. Finley, Director of NOAA's National Fishery Education Center, the 30- × 48-inch charts are printed on washable, nonglare, plasticized paper that hangs flat against a surface without curling. A list of common and scientific names of the shellfish is included, as well as artwork showing the natural habitat. The first five charts are titled: Marine Fishes of the North Atlantic ($2.80), Marine Fishes of the North Pacific ($2.80), Marine Fishes of the California Current ($2.80), Marine Fishes of the Gulf and South Atlantic ($2.80), and Fishes of the Great Lakes ($2.65).

Copies of Mollusks and Crustaceans of the Coastal U.S. may be obtained from Government bookstores and the Superintendent of Documents, Washington, DC 20402, for $3.20.

NOAA Scientists Find and Observe Herring Spawning Grounds off Massachusetts Coast

Herring spawning grounds have been located and observed by scientists of the National Oceanic and Atmospheric Administration's National Marine Fisheries Service during recent diving explorations off the coast of Massachusetts. Scientists believe that such observation will give them an insight into the reasons for declines in herring populations and may assist them in determining what can be done to increase future populations.

Richard A. Cooper, chief of the exploration party and a scientist at the NMFS Northeast Fisheries Center, Woods Hole-Narragansett, said this is the first time they were able to observe in detail herring spawning grounds. The dives were a continuation of activities in a 5-year Commerce Department study to learn more about herring spawning. The principal area of investigations was the southern half of Jeffrey's Ledge, which is approximately 20 miles northeast of Cape Ann, Mass., in the Gulf of Maine. Close contact with several commercial draggers and gill netters fishing for groundfish that concentrate over the egg beds shortly after spawning provided the team with its first evidence as to location and times of spawning.

Scuba dives were made in two spawning areas nine miles apart, to depths of 132 feet. The dives were made within "no decompression" limits which restricted divers to 8-9 minutes of bottom time. Several dives also were made by the U.S. Navy Camera Sled, "Snoopy." Extensive photographic documentation of the ocean bottom and of the developing herring eggs was conducted in conjunction with the dives. Cooper and his staff were assisted by personnel from the Naval Undersea Center, San Diego; Army Corps of Engineers; and NOAA's Manned Undersea Science and Technology office.

Preliminary results indicate certain characteristics common to both spawning grounds: The bottom temperature at the time of spawning was 48.2°-50.0°F.; the bottom was hard and irregular; i.e., boulders, rocks, gravel and shell; the distribution of eggs was relatively uniform over the bottom and covered a 0.2-0.4 square-nautical-mile area. Government scientists plan to conduct a complete "before-during-after" ecological study of the herring spawning this fall.

Southeast Coastal Navigation Facilities Inspected

A 4-month inspection by the Commerce Department's National Oceanic and Atmospheric Administration of marine and navigational facilities from Cape Henry, Va., to Key West, Fla., is being conducted for a new edition of the government's *Coast Pilot* for that area. The inspection, which began in April, is being conducted by Pamela R. Chelgren of Seattle, Wash., who is visiting such ports as Charleston, S.C.; Wilmington, N.C.; and Miami, Port Everglades, Palm Beach, Jacksonville, and Key West in Florida.

The inspection is being made for *Coast Pilot*, a publication issued for commercial shipping and recreational boating by NOAA's National Ocean Survey. It will contain important navigational information which cannot be shown graphically on the nautical charts including details concerning waterways, harbors, anchorages, navigation regulations, weather, marine and port facilities, routes, and prominent landmarks.

Chelgren will meet with officials of Federal, state and local marine navigation agencies, including the Coast Guard and Navy personnel, port authorities, harbormasters, merchant seamen, pilots and others involved in marine affairs and regulations.

The field inspector will also examine marinas and their facilities, question the Army Corps of Engineers concerning plans for deepening channels, confer with Customs, Immigration and Naturalization, and Public Health officials regarding regulations and inspection requirements, and talk to port authorities on such varied subjects of interest to mariners as the depth of water at piers and regulations concerning anchorages.

Inspections are conducted about every five years to update the eight *Coast Pilot* publications.

Between 1885 and 1889, four local *Coast Pilots* were published covering the Atlantic Coast from Cape Henry to Key West. The first complete edition of the area was published in 1895. Since then, 15 additional editions have been published, the most recent in 1970.

Foreign Vessels Draw CSFR Violation Fines After Notifications

On 5 December 1974, the U.S. Coast Guard and the National Marine Fisheries Service began enforcing a U.S. law which prohibits the taking by any foreign vessel of Continental Shelf Fishery Resources (CSFR) appertaining to the U.S. Continental Shelf. All foreign governments were notified of these regulations in advance by the U.S. Department of State. In addition, U.S. Coast Guard officers have been advising foreign fishing vessels of the law whenever they boarded a foreign fishing or fishery support vessel.

Despite the advance notifications, The stern factory trawler *Tontini Pesca-4* was seized by the U.S. Coast Guard approximately 100 miles south of Cape Cod on 31 January 1975, according to the Law Enforcement Division, National Marine Fisheries Service. Coast Guard personnel observed the Italian vessel hauling starfish in her net. Since starfish dwell on the U.S. Continental Shelf, the vessel was boarded. A search located four lobsters in the cold storage hold; an additional search produced 20 kilograms of frozen lobster tails and claws, five more whole lobsters and about 30 crabs. The seizure of the vessel was authorized by the Coast Guard and the vessel was taken to Governors Island, New York City, pending arraignment in U.S. Federal Court.

On February 3, the vessel's captain was arraigned in the U.S. District Court; at the same time, the U.S. Attorney filed a civil action for the forfeiture of the Italian vessel, its gear, cargo, and stores. A settlement was reached on February 5 with the payment by the

vessel owners of a $25,000 fine. The captain was released on condition of satisfactory compliance of a one-year probationary agreement.

These court actions were civil in nature. The civil case can be processed more quickly and the master is not left with a criminal record. Criminal actions by the U.S. Attorney can be brought, however, particularly if the captain is uncooperative, or if the offence is more serious.

On February 11 another Italian stern trawler (*Antonietta Madre*) was seized by the U.S. Coast Guard. The vessel had previously been boarded on February 1 and her captain had been cautioned not to take any lobsters as such activity would violate the provisions of the newly enacted CSFR law. When lobster was discovered on board, the vessel was brought to New York and the captain was arraigned before a U.S. magistrate. On February 14 the vessel owners paid a $40,000 fine, and the vessel and its crew were released and allowed to depart. The captain's release was provisional and he was placed on probation for one year.

Between February 7 and 9, three Spanish fishing vessels were boarded and inspected by the Coast Guard as they were conducting demersal (bottom) fishing operations. The vessels were incidentally taking crab and lobster, but were immediately returning them to the sea. The captains were advised of CSFR requirements, and no further action was taken.

Subject to certain technical considerations, the CSFR law, which went into effect on 5 December 1974, is being enforced by the U.S. Coast Guard in all waters over the U.S. Continental Shelf. Foreign vessels may be boarded and/or seized for the following practices: (1) Fishing with gear designed specifically to catch CSFR (whether or not such catch has been made); (2) Retaining CSFR taken incidentally (not immediately returning the Continental Shelf creatures to the sea); (3) Resetting gear in an area where there is a known concentration of CSFR, after the Coast Guard had warned them not to fish there; and (4) Catching two separate CSFR specimens within one year, even if they are immediately returned to the sea.

Herring, Hake Stocks Counted by Computer

A method that can provide precise and rapid estimates of certain fish stocks using a computerized, hydroacoustic system has been developed by a Sea Grant team at the University of Washington.

Capping a six-year effort backed by the Commerce Department's National Oceanic and Atmospheric Administration through its National Sea Grant Program, the Washington research team has devised an acoustic system consisting of: (1) Echo sounders that transmit sound pulses and receive echoes from the fish; and (2) A computer system which converts the fish echo data into estimates of fish populations, and is used either on ships to produce "real time" information on fish abundance, or in the laboratory where it processes data collected on tape recorders at sea. NOAA's National Marine Fisheries Service is now using the sophisticated acoustic gear for surveys of hake stocks off the Pacific Coast and plans to use it to assess herring and pollock off Alaska.

Stanley R. Murphy of the University of Washington Marine Acoustics Group and leader of the Sea Grant research team said, "standard instruments still can be used effectively by fishermen and scientists to estimate gross abundance or general location of fish stocks, but they are not reliable enough for scientific management of many fish stocks."

A primary benefit of the new acoustic system is that it allows much more timely assessment than traditional methods such as tagging or analysis of the catch data of commercial fishing fleets. Traditional assessment methods are often so time-consuming that by the time effective management plans can be instituted the fish stock in question is already in danger of being seriously depleted.

The heart of the new system is the computer programmed to carry out "echo integration." The intensity of the fish echoes the sounder receives is directly proportional to the number of fish. The sounder converts the echoes to electrical voltages, and these are added together (integrated) by the computer. When combined with information on the species of fish obtained from actual net catches, the system is capable of producing reliable estimates of the number and average size of fish stocks.

The Sea Grant team is continuing its research to determine the applicability of these techniques to high-density fish schools that occur in such species as anchovies and herring. This work has been aided by the availability of salmon of various sizes being grown in aquaculture pens. The scientists also are investigating the feasibility of a network of fixed-location acoustic monitors that could be used to determine fish population characteristics at specific points such as sewage outfalls or power plant discharges, and the timing and size of migrating fish populations such as the commercially valuable salmon.

The first "on line" test of an early model of the system came at the request of the Washington State Department of Fisheries. Herring schools in the south Puget Sound area provide the State with a half-million-pound annual harvest for the baitfish industry. Sport fishermen groups, which had viewed this commercial fishery as a threat to the stock upon which salmon feed, sought to have the herring fishery closed in 1971. At that time there was no accurate assessment of the stock size.

The Sea Grant group undertook an immediate study of the stock and came up with data showing that only about one percent of the herring was being harvested. "Had the fishery been arbitrarily closed awaiting the outcome of traditional stock assessment, a process that might have taken as long as a year, an industry with an annual landed value of almost $500,000 would have been needlessly curtailed," Murphy said.

Working with Murphy on the Sea Grant project have been John E. Ehrenberg, William Acker, and James Green of the Applied Physics Laboratory, Dean W. Lytle of the Department of Electrical Engineering, and Richard E. Thorne and Ole A. Mathisen of the Fisheries Research Institute, all of the University of Washington.

Soviet-U.S. Fishery Claims Are Studied

The U.S.-USSR Fisheries Claims Board was established to provide an efficient and amicable means to settle claims brought by a national of either country against a national of the other country for financial loss resulting from damage to fishing gear or fishing vessels, or by loss of or damage to catch. An agreement signed in February 1973 established a Fisheries Claims Board to examine allegations of loss or damage sustained in the northeastern Pacific, including the Bering Sea. The agreement was amended in June 1973 to include consideration of claims arising in the western Atlantic. There are now two parallel Boards, one in Moscow and the other in Washington, D.C. Each Board has two Soviet and two American members. The Board in Washington began to function officially in early 1974, with the arrival of two Soviet representatives: Y. A. Znamenskiy and A. G. Afanasyev. The U.S. representatives are C. J. Blondin and C. J. Maguire.

A notice of the establishment of the Board was published in the Federal Register of 12 May 1974, and rules of procedure were formulated. The records of all individuals who have previously filed complaints with the U.S. Department of State alleging Soviet responsibility for gear loss or damage were turned over to the Board and the individuals were so advised by letter.

Fishermen may bring claims before either Board within one year of an incident's occurrence, except that, for incidents which occurred two years prior to the entry into force of the agreement, claims may be brought before either Board within two years of an incident, or within one year of the entry into force of the agreement, whichever is longer. After examining the evidence in each claim, the Board recommends a settlement. Cases in which the Board recommends payment by the Soviet Government are reviewed by that Government before payment is authorized. The recommendations of the Board are not binding on any party, and a claimant may ask the Board to reconsider its recommendation.

As of 1 March 1975, 55 allegations of damage had been presented to the Board. Of these, 13 cases are closed; in one case, the Board has determined that the record did not support the claim of involvement by Soviet vessels, and in 12 other claims the Board recommended payments by the Soviet Government totaling $82,266. Six cases stem from incidents which occurred prior to the period which the Board by agreement may consider. Four cases await additional documentation before the Board can dispose of them. There remain 32 claims under active consideration.

Parties desiring to submit a claim to the Board should obtain a copy of the rules of procedure which outline the filing procedures. A copy can be obtained from the Assistant Director for International Fisheries, National Marine Fisheries Service, Washington, DC 20235.

Well Travelled Tuna Taken Off Hawaii

The Honolulu-based sampan *Buccaneer* entered port last fall carrying in its load of skipjack tuna at least one that should have been tired. About 30 miles south of Honolulu the crew of the *Buccaneer* had recovered a skipjack tuna that was tagged by the Inter-American Tropical Tuna Commission off the southern coast of Baja California in June 1973.

According to fishery scientists at the Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, the fish had grown from an estimated 4½ pounds to a whopping 21 pounds, and from 18 to almost 30 inches in length in its 14 months of freedom. And it had swum at least 2,750 miles.

This was the ninth tagged skipjack tuna to be recovered in the central Pacific over a period of 12 years. Eight of these fish were recaptured in Hawaiian waters. They had all been caught, tagged, and released in the same general area of the eastern Pacific as part of an on-going program to study the migration patterns of this sturdy pelagic species.

Information resulting from the study is valuable to the National Marine Fisheries Service Honolulu Laboratory in its continuing work to determine the size of the skipjack tuna resource of the Pacific and the movements of this resource, knowledge that is important to an expansion of the Hawaiian fishery.

The fish taken by the *Buccaneer* was the second tagged skipjack tuna caught near Hawaii this year. In June the MV *Sunfish* also recovered a skipjack tuna bearing an IATTC tag. These two fish had been released within 3 days of one another.

With one exception, all of the tagged skipjack tuna recaptured in the Hawaiian fishery were taken in years of below-average catch. By late summer the 1974 skipjack tuna catch in Hawaii was estimated at 2,700 metric tons, considerably below the long-term yearly average of 4,500 metric tons.

Fisheries Attache Named For Africa

William B. Folsom is the new U.S. Regional Fisheries Attache for Africa with the Department of State. He began his official duties in March 1975 at the Consulate General of the United States of America in Casablanca, Morocco. Folsom replaced Norman L. Pease who was assigned to Copenhagen, Denmark. Folsom's assignment also marked the opening of the new post in Morocco. The Regional Fisheries Attache was formerly posted in Abidjan, Ivory Coast.

Folsom was a Foreign Affairs Officer with the Office of International Fisheries, National Marine Fisheries Service, NOAA, U.S. Department of Commerce prior to his nomination. There he was responsible for reporting on the fisheries of Africa, Asia, and Latin America. He joined the National Marine Fisheries Service in 1971 after receiving a Master of Philosophy degree in International Affairs from the George Washington University where he specialized in the politics and history of Sub-Saharan Africa. Folsom also received a Master of Arts in International Affairs from George Washington University. Folsom was graduated from Tufts University in 1965. Son of a retired U.S. Foreign Service Officer, he has lived in Haiti, Hungary, China, Mexico, and Greece.

ROK Expands Catch of Large Whales

Since 1962 the annual catch of whales by the Republic of Korea has increased significantly according to the Office of International Fisheries, National Marine Fisheries Service. The total number of whales caught in 1973 was 886, compared to 252 in 1962, a 352 percent increase (Figure 1). Between 1969 and 1970, a record 75 percent increase was recorded.

Between 1962 and 1968, small whales were the largest part of the overall catch; however, by 1969 this trend was reversed (Figure 2) and by 1973 a total of 43 large whales were caught for each small one (97 percent vs. 3 percent). Large whales are caught mainly between April and June, when 50 percent of the total is taken. The season for small whales is primarily from March to July, with the catch of May accounting for 60 percent of the total (Figure 3). In 1973, the minke whales comprised the major part of both the large and small whale catch.

Changes in demand and currency valuations have affected the annual landing values, which have fluctuated from year to year, thereby making it difficult to discern any particular trend. In 1973, the value of the Korean whale harvest was about $252,000.

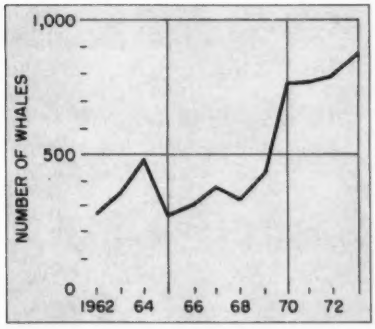

Figure 1.—Number of whales caught by the Republic of Korea, 1962-73.

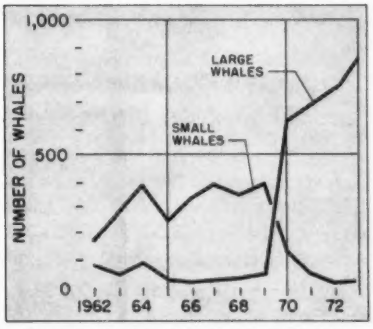

Figure 2.—Number of large and small whales caught by the Republic of Korea, 1962-73.

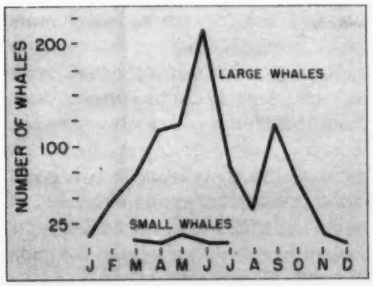

Figure 3.—Number of whales caught by the Republic of Korea in 1973, by month.

Low Prices Push Danish Cod into Meal and Oil

Significant quantities of cod landed early this year by Danish fishermen in Danish ports did not receive the minimum price set by the European Economic Community (EEC), and were taken off the market and sold for reduction to fish meal and oil according to the U.S. Embassy, Copenhagen, Denmark. Normally such fish would be processed into fresh fillets or frozen fillets and blocks. A major share of Danish exports of frozen cod blocks is exported to the United States.

The minimum price for gutted cod of the first three size categories, and for quality grades Extra A and B landed in Denmark, is 2.34 kroner per kilogram (about US$0.19 per pound). Minimum prices are lower for smaller fish and for fish of lesser quality.

Cod landed by members of the Danish Producers Organizations (PO) is taken off the market if the quoted price is less than the minimum price. In addition, the cod cannot be exported as fresh or frozen fish because such exports would disturb normal market prices. Hence high-quality cod must be sold for reduction. Only PO members (about two-thirds of the Danish fishermen) are guaranteed the minimum price for fish which they land. Fish landed by non-PO fishermen may be sold at less than the minimum price.

The sluggish export market in the United States and elsewhere, and unexpected heavy landings in Denmark are blamed for the low prices. The industry reportedly believed the situation to be temporary and expected prices to soon rise to at least the minimum price level.

Program Aids Canada Groundfish Industry

Canada's Minister of State for Fisheries Roméo LeBlanc announced a new short term federal government plan in December for Canadian fishermen, trawler operators and processors as a first step toward rehabilitating the Canadian groundfish industry. Expected to cost $20 million, the programs were designed to keep the groundfish fleets in operation during the winter months while longer term solutions are sought. Studies are under way to restructure the fishing industry to make it more viable.

The Canadian fishing industry, like that of most fishing countries of the world, has been hard hit by escalating costs resulting from worldwide inflation, high fuel and gear costs, low landings and weak markets. As a result, fishermen's incomes have been adversely affected, companies have suffered substantially and many plants have operated on a part-time basis. While these factors, taken together, threaten the continuation of the Canadian groundfish industry, the longer term prospects look bright for Canadian fishermen, LeBlanc said.

The new $20 million plan comprises three programs, the first of which was designed to lessen the immediate impact of rapidly rising costs faced by the frozen groundfish industry. This program applied to operations carried out from 1 January 1975 to 30 April 1975.

Second, to assist the reopening of seasonal plants this spring in northern Newfoundland, Labrador, and Quebec's lower north shore which suffered serious losses in the early season of 1974 because of late ice conditions,

working capital loans have been made available. This program was intended to assist only those plants which had exhausted their credit facilities as a result of the adverse ice conditions in 1974.

Third, to help meet world food shortages, the Canadian government moved to provide increased amounts of canned groundfish products to Canadian food aid programs. The programs are administered by the Fisheries Prices Support Board through the Regional Offices of the Department.

Finland Marks New 8-Mile Contiguous Fishing Zone

Effective 1 January 1975, Finland established an 8-nautical-mile Contiguous Fishing Zone adjacent to its 4-nautical-mile Territorial Sea, reports the American Embassy in Helsinki. Where the zone overlaps the territorial sea or fishing zone of another nation, a center line will be drawn equidistant between each state.

Finland has claimed the exclusive right to supervise all fishing activities within the zone. Provisions have been made, however, to allow those states bordering the Baltic, which have traditionally fished within the zone, to continue to do so until 31 December 1976. In addition, Danish, Icelandic, Norwegian, and Swedish citizens shall have the right to fish for domestic consumption and recreational purposes within the zone without time limitations.

Japan to Buy Red Crabs from Mexico

The Japanese trading firm Nippon Heiwa Boeki, Tokyo, has concluded a contract with the Mexico Fisheries Public Corporation to purchase 100,000 tons of red crabs, described as "Langostilla", annually over a three-year period according to a report in *Suisan Keizai Shimbun*. The red crabs, which have a body length of 10-12 centimeters (3.9-4.7 inches), occur along the entire western coast of Baja California. They reside in the bays and inlets from January to July and move offshore during August-December where they are preyed upon by certain whales. The Mexican Government estimated the red crab population to be around one million tons and, based on the assumption that a 10 percent harvest would not endanger the population, sought users to effectively utilize the resource.

The Japanese firm plans to build refrigeration, drying, and processing plants at San Carlos in southern Baja California costing about 1,000 million yen (approximately US$3.4 million at 290:1). The San Carlos-based enterprise will purchase the red crabs harvested by the Mexican corporation's boats which began fishing in March. Until the plant is completed, existing facilities will be used. Plans call for shipping the red crabs to Japan where they will be initially processed into animal feed although future technological developments may open up other uses for them.

Norway Proclaims Trawl-Free Zones

The Norwegian Government proclaimed three no-trawling zones in the Norwegian and Barents Seas early this year following negotiations with several foreign governments whose fishermen would be affected. The zones, to protect coastal fishermen and their gear, extend up to 35 miles from shore[1] and will be closed to foreign trawling from mid-fall to early spring, according to Norinform, the Norwegian Information Service.

Norway originally sought four trawl-free zones with longer closure periods[2], but to gain acceptance of the major fishing nations affected (USSR, France, United Kingdom, Federal Republic of Germany), its negotiators made some concessions. These included deletion of the proposed Nysleppen zone, a reduction of the Jennegga-Malangsgrunnen zone by about one-seventh, and in policing policy. Norwegian fisheries surveillance vessels will have the power to board and inspect foreign vessels encountered in the prohibited areas, but they can only request them to leave the zones. Prosecution of offenders is up to their respective national authorities.

The trawling ban will last for five months in each zone: 1 October-1 March in the Nordbanken-Øverbanken zone; 1 November-31 March in the Hjelmsøybanken zone; and 20 October-20 March in the Jennegga-Malangsgrunnen zone.

Norinform also reports some disappointment in Norwegian fishing circles with some of the concessions as well as satisfaction with the fact that the zones have been recognized in principle. The Norwegian Government's next step is the extension of the fishing limits off northern Norway to 50 nautical miles. This move will not be unilateral, according to Norwegian Minister Jens Evensen, but will be achieved through negotiations which could take the rest of the year.

[1]Norway has a 12-mile fisheries limit.
[2]See "Norway Seeks Partial Cod Trawling Ban," *Marine Fisheries Review*, Feb. 1975, 37:2 (44).

Japan's Per Capita Meat, Fish Consumption Grows

Japan's per capita fish and shellfish consumption in 1973 was 34.3 kilograms (75.6 pounds), 2.4 percent above the 33.5 kilograms (73.8 pounds) per person in 1972 according to data compiled by the Japanese Agriculture and Forestry Ministry and published in *Suisan Tsushin*. The increase was attributed to larger saury and sardine landings. Per capita meat consumption in 1973 was 16.2 kilograms (35.7 pounds), a 5.2 percent gain over 1972. Pork and poultry meat consumption increased though beef and whale meat consumption declined. The self-sufficiency rate for meats was 78 percent compared with 81 percent in 1972.

Norwegian Marketer Sees Less Fish, More Money

The Norwegian fish marketing organization Frionor Norsk Frossenfisk A/L recorded a drop of about 13,000 tons in the quantity of fish products sold during the financial year ending 30 June 1974. Despite this, the company had an increase in gross earnings of 30 million kroner. The company thus reached a total turnover of nearly 600 million kroner for the approximately 70,000 tons of Frionor products which were sold in nearly 30 different markets during 1973-74. During the financial year ending 30 June 1973, the company sold about 83,000 tons of fish products. The transition to a higher degree of processing of the company's products is given as the primary reason for the value of output rising 5.5 percent at the same time as the quantity produced has sunk by nearly 20 percent.

Source: *Norinform*.

Rate Schedule, Terms Amended for Loran-C

Planned expansion of the Loran-C navigation system to accommodate the entire Coastal Confluence Zone of the continental United States has prompted the Coast Guard to expand the present Loran-C rate structure and amend its terminology, that agency reports. The Coastal Confluence Zone (CCZ) includes U. S. coastal waters extending to the 100-fathom curve or to fifty miles offshore, whichever is further.

Expansion of the Loran-C navigation system is planned to cover waters of the Gulf of Mexico, the west coast and Gulf of Alaska. To facilitate this planned expansion additional Loran-C rates will be required. Details on the new rate structure were published in the Federal Register of 11 February 1975.

Present and potential owners and manufacturers of Loran-C receivers are advised that most present receiver designs will not accommodate the new Loran-C rate structure; however, use of these receivers in the CCZ will not be affected by the change to the Loran-C rate structure. Existing Loran-C rates will be used to provide coverage of the CCZ; only the terminology in which they are identified will change. Any further expansion of the navigation system beyond the CCZ, such as inland, would require additional new rates which present receivers will not accommodate.

Continuous Vessel Radio Watch is Established to Get Marine Weather Data

The Coast Guard has established a continuous radio watch on vessel voice frequencies to gather marine weather observations requested by the National Weather Service. The weather observations will supplement reports received from regular weather reporting stations and ships which may be too far from a storm center to provide accurate weather conditions in coastal waters.

The Coast Guard radio watch is also expected to augment collection of reports which may aid the Coast Guard in conducting its Automated Mutual-assistance Vessel Rescue (AMVER) program. AMVER is a worldwide ship location reporting system operated by the Coast Guard and used primarily in search and rescue and other emergency type situations.

Coast Guard communication stations participating in the radio guard are in Washington, D.C., New Orleans, La., San Francisco, Calif., Kodiak, Alaska, and Honolulu, Hawaii. The Coast Guard communication station in Boston, Mass., may be added later if ships respond to the program. The appropriate carrier and assigned frequencies for ship and coast stations are as follows:

Washington/NMH, New Orleans/NMG, San Francisco/NMC, Honolulu/NMO

	Ship stations		Coast stations	
Guard period	Carrier freq (kHz)	Assigned freq (kHz)	Carrier freq (kHz)	Assigned freq (kHz)
24-hr	4094.8	4096.2	4393.4	4394.8
24-hr	6207.2	6208.6	6521.8	6523.2
24-hr	8226.8	8228.2	8760.8	8762.2
Upon request	12365.0	12366.4	13144.0	13145.4
Upon request	16495.0	16496.4	17290.0	17291.4
		Kodiak/NOJ		
24-hr	6207.2	6208.6	6521.8	6523.2

Anyone interested in participating in the weather observations reporting part of the program should contact the Office of Technical Services (W52), National Weather Service, 8060 13th Street, Silver Spring, MD 20910. Information on participating in the AMVER phase of the program can be obtained by writing to the AMVER Center, Atlantic Area Coast Guard, Governors Island, New York, NY 10004. Technical questions on the program should be directed to the Commandant (G-OTM/74), U.S. Coast Guard, 400 7th Street, S.W., Washington, DC 20590.

Stocked Cohos Bolster Alaska Salmon Fishery

Stocked silver salmon returning to Alaska's Resurrection Bay last summer contributed 5,660 fish, or over 30 percent of the bay's total sport harvest of 18,600 silver salmon, the Department of Fish and Game reports. The fish resulted from fingerling plants made in rehabilitated Bear Lake in 1972 and smolts stocked in Seward Lagoon during 1973 by the sport fish division of the Department of Fish and Game.

The majority of the marked silver salmon which escaped through the Resurrection Bay sport fishery returned to spawn in Bear Creek from late August to mid-November. Of the 2,600 fish which escaped, more than 1,600 were passed above Bear Creek weir for natural spawning in Bear Lake inlet tributaries. The remaining 1,000 silvers were retained at the Bear Creek holding facility and were artificially spawned.

Ted McHenry, department research biologist, noted that the bulk of the department's Southcentral Alaska silver salmon egg requirements were obtained from the Bear Lake return. Approximately 2.7 million eggs were taken from 660 silver salmon, then incubated and reared to fingerling stage at the Fire Lake hatchery at Eagle River.

Several hundred thousand of these fingerlings will be restocked in Bear Lake this summer to augment natural silver salmon production for the rapidly expanding Resurrection Bay sport fishery. The remainder of the eggs will be utilized at gravel incubation sites and for freshwater smolt rearing and stocking in Southcentral Alaska lakes.

CG Issues Marine Sanitation Rules

The Coast Guard has issued regulations governing the design, construction, testing, certification, and manufacture of marine sanitation devices for vessels. The regulations, which apply to vessel owners and marine sanitation device manufacturers, were published in the 30 January 1975 issue of the Federal Register.

On 30 January 1977 the regulations will go into effect for "new" vessels. "New" vessels are classified as any vessel the construction of which began after 30 January 1975. For "existing" vessels, those the construction of which began before 30 January 1975, the new regulations will become effective 5 years thereafter.

The regulations are consistent with water quality standards published by the Environmental Protection Agency (EPA) pursuant to the Federal Water Pollution Control Act. However, it was recommended by a joint Coast Guard/EPA working group that the EPA's "no-discharge" standard be revised to permit the installation on new

and existing vessels, of certified "flow-through" devices, which provide adequate treatment of sewage. The Coast Guard/EPA working group was formed to reassess the "no-discharge" standards after a review of more than 150 comments concerning the standards from the boating public.

Based on the probable revision of the "no-discharge" standard during the next 12 months, the Coast Guard regulations contain a waiver to permit certified "flow-through" devices to be installed on "new" vessels for one year, thereby effectively treating a "new" vessel constructed during this 1-year period as an "existing" vessel. The new regulations will also permit the recognition of marine sanitation device testing facilities which will certify marine sanitation devices for the boating public.

Publications

Recent NMFS Scientific Publications

Data Report 91. Owen, R. W., Jr., and C. K. Sanchez. "**Phytoplankton Pigment and Production Measurements in the California Current Region, 1969-72.**" November 1974. 185 p. on 3 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Phytoplankton production, standing stocks, and some relevant environmental characteristics were for the first time systematically measured in the California Current system during the period from 1969 through 1972. This work describes the systems and methods of measurement, and presents the data obtained.

Data Report 92. Misitano, David A. "**Zooplankton, water temperature, and salinities in the Columbia River estuary, December 1971 through December 1972.**" August 1974. 31 p. on one microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Sampling was conducted at seven stations in the Columbia River estuary throughout 1972 to provide baseline information on species diversity, relative abundance, and seasonal occurrence of zooplankton, as well as ambient water temperatures and salinities.

Data Report 95. McNulty, J. Kneeland, William N. Lindall, Jr., and Ernest A. Anthony. "**Data of the Biology Phase, Florida portion, Cooperative Gulf of Mexico Estuarine Inventory.**" September 1974. 229 p. on 4 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Data of the Florida portion of the Biology Phase of the Cooperative Gulf of Mexico Estuarine Inventory are recorded. They consist of the catches made by seine, trawl, and plankton net at Chokoloskee in the Ten Thousand Islands, Bokeelia in Charlotte Harbor, Maximo Point in Tampa Bay, Atsena Otie Key near Cedar Key, and at the mouth of the St. Marks River. Monthly samples were taken from April 1968 through March 1969. Water temperature and salinity at the times of sampling are recorded.

Data Report 96. Hughes, Steven E. "**Groundfish and Crab Resources in the Gulf of Alaska—Based on International Pacific Halibut Commission Trawl Surveys, May 1961-March 1963.**" October 1974. 87 p. on 2 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Results of a trawl survey of groundfish and crab resources occurring between Cape Spencer and Unimak Island, Alaska, are presented. The survey was conducted by the International Pacific Halibut Commission during 1961-63; catch records from 1,272 stations were recently analyzed and prepared by the Northwest Fisheries Center. Information presented shows seasonal patterns of geographic and depth distribution, in addition to relative abundance of all major species occurring in the Gulf of Alaska. For each group (flatfish, roundfish, rockfish, elasmobranchs, and crab) and major species, a brief narrative of results is accompanied by figures showing percentage and catch rate information by area-season-depth categories. In addition, 40 charts show detailed seasonal information on eight major groundfish as well as king and Tanner crabs.

Data Report 97. Pullen, Edward J., and Lee Trent. "**Hydrographic Observations from a Natural Marsh and a Marsh Altered by Dredging, Bulkheading, and Filling in West Bay, Texas.**" October 1974. 15 p. on 1 microfiche. For sale by U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22131.

ABSTRACT

Hydrographic data were collected from a natural marsh and a marsh altered by dredging, bulkheading, and filling in West Bay, Texas. Water samples were taken at 2-wk intervals during the day and night at 10 stations from 25 March to 21 October 1969. This report contains the location, depth, date, and time the samples were taken and corresponding measurements of water temperature, salinity, dissolved oxygen, dissolved organic nitrogen, nitrite, total phosphorus, inorganic phosphate-phosphorus, pH, carbon dioxide, total alkalinity, carbonate alkalinity, and turbidity.

Fishery Facts 7. Hipkins, Fred W. "**A Trapping System for Harvesting Sablefish, *Anoplopoma fimbria*.**" November 1974, 20 p., 17 figures.

ABSTRACT

An improved method of commercial fishing for sablefish, commonly known as black cod (not related to

the family of codfishes), is now used by commercial fishermen from California to Alaska. Fish are captured and impounded in lightly constructed, baited traps. The traps are collapsible (they fold down) but are rigid when set out to fish. They can be completely covered with webbing or steel wire mesh. Fish impounded in the traps, which are attached to groundlines, are alive and in excellent condition when brought aboard the fishing vessels. The traditional setline method for fishing sablefish requires considerably more bait, larger fishing crews, and many more hours of work per day to catch a comparable amount of sablefish.

Details of the trapping gear, setlines, and buoylines, plus the vessel equipment, fishing instructions, and locations of traditional fishing grounds are described.

Fishery Facts 8. Lane, J. Perry. "**Sanitation Recommendations for Fresh and Frozen Fish Plants.**" November 1974, 39 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

The problem of sanitation in fish processing plants is receiving increasing attention from Federal and State regulatory agencies, as well as private industry. This article covers recommended guidelines that can assist the processors of fresh and frozen fish in evaluating their existing sanitation practices or in establishing new ones.

Fishery Facts 9. Gutherz, Elmer J., Anthony F. Serra, and Edward F. Klima. "**Design and Materials Used in Construction of a 16-Foot Shrimp Trawl.**" December 1974, 14 p., 12 figs., 1 table. (No abstract)

Fishery Facts 10. Parker, R. O., Jr., R. B. Stone, C. C. Buchanan, and F. W. Steimle, Jr. "**How to Build Marine Artificial Reefs.**" December 1974, 47 p., 21 figs., 1 table, 4 app. figures.

ABSTRACT

Artificial reefs provide or improve rough bottom habitat and offer fishery scientists and administrators an effective technique to conserve and develop coastal fishery resources. With careful planning and organized efforts, local reef committees can build reefs to improve fishing and contribute to the recreational and financial growth of coastal communities. Advice and procedures are presented for: 1) selecting construction materials, 2) determining a suitable reef site, 3) obtaining permits, 4) buoying the reef, and 5) preparing, transporting, and placing reef-building materials. Included in appendixes are instructions for preparing permits, addresses of Federal and State agencies involved in approving or funding reef construction, and addresses of manufacturers of materials and equipment.

NOAA Technical Report NMFS SSRF-681. "**Physiological response of the cunner, *Tautogolabrus adspersus*, to cadmium.**" October 1974. 33 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

The cunner, *Tautogolabrus adspersus*, was exposed to six concentrations of cadmium, as cadmium chloride ($CdCl_2 \cdot 2\frac{1}{2} H_2O$), for 96 h. At the end of this exposure period, tests of blood serum osmolality and gill tissue oxygen consumption were performed. High levels (48 ppm) of this metal resulted in abnormally high serum osmolality, and an exposure as low as 3 ppm reduced the normal rate of oxygen consumption. Both of these parameters may be related to observed tissue damage.

The histopathological effects of acute exposure of the cunner to cadmium were manifested in the kidney, intestine, hemopoietic tissue, epidermis, and gill. Few significant changes were noted in fish exposed to concentrations less than 48 ppm. The results implicate renal failure as the probable cause of death subsequent to acute exposure to cadmium.

Clearance of intracardially injected bacteria from the blood of cunners exposed to 12 ppm cadmium was examined. The rate of bacterial uptake in the cells of the liver and spleen was increased, but the bacterial death rate within these cells was decreased. Exposure of fish at 3 to 24 ppm failed to influence antibody production against sheet red blood cells.

The activity of two liver enzymes changed significantly with exposure to cadmium. Aspartate aminotransferase was lower in the exposed fish, and a magnesium-linked oxidoreductase in exposed fish required 10 times as much added magnesium to reach the same level of activity as in the control fish.

Chemical analyses were made for uptake and clearance of cadmium from exposed cunners. In the uptake study, cadmium residues averaged 8.5 times higher in liver than in gills. In the clearance study, substantial reductions in cadmium residues were found in the gills and blood of fish held in clean seawater for 6 wk after exposure to cadmium, as compared to fish sacrificed immediately after exposure. Muscle and carcass samples from the "cleared" fish showed little reductions in cadmium levels.

Sea Grant Publications Review Shrimp Diseases and Fisheries Science

Shrimp diseases, an important factor in reducing natural populations and a major consideration for mariculturists, is the topic of the new Texas A&M University publication **Handbook of Shrimp Diseases**, by S. K. Johnson, fish disease specialist for the Texas Agricultural Extension Service in the Department of Wildlife and Fisheries Science. Published by A&M's Sea Grant Program, the book contains detailed descriptions and illustrations of common parasites of shrimp. It is intended as a guide for shrimp mariculturists, commercial fishermen, and others interested in abnormal shrimp conditions. Single copies of the 20-page booklet are available free from the Sea Grant College Program, Texas A&M University, College Station, TX 77843. Request publication TAMU-SG-75-603.

The Sea Grant Program, Virginia Polytechnic Institute and State University, has published **Introductory Fisheries Science** by Robert T. Lackey. This 275-page book covers the major disciplines of fisheries science (management, biology, theory, population dynamics, aquaculture, planning, and economics) from a broad, principle-oriented approach. Copies, $5.00 each, may be obtained from the Sea Grant Program, Extension Division, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. Checks should be made payable to VPI&SU Sea Grant.

Appointments, Abalones, and Mackerel

. . . . Development of **a coho salmon sport fishery inside San Francisco Bay** is being tested with young, pen-reared fish according to the California Marine Advisory Programs *Newsletter*. Several thousand half-pound cohos were tagged and released into the bay last fall and an expected 40,000 will be released this year. Project cooperators include the University of California Sea Grant Program, National Marine Fisheries Service, California Department of Fish and Game, and the San Francisco Tyee Club . . . .

. . . . **Donald H. Rosenburg, associate professor of marine science,** University of Alaska, has been appointed director of the institution's Sea Grant Program, the University reports. Rosenburg joined the University's Institute of Marine Science in 1964 and has coordinated marine programs for the Sea Grant Program. He succeeds David M. Hickok who directed the Alaska Sea Grant Program since it began in 1970 . . . .

. . . . A king mackerel tagging study by Florida's Department of Natural Resources (DNR) **seeks data on the species' population, movements, and migration** according to *Florida Conservation News*. Important to that state's commercial and sport fishermen, over 6 million pounds of king mackerel are landed in an average year and hook and line anglers take almost 10 times as much as commercial fishermen by DNR estimates. Rewards are being paid for recovery of mackerel tags by Florida's DNR . . . .

. . . . The **National Sea Grant Association named Stanley R. Murphy** as its president-elect at its seventh annual meeting in Seattle, Wash. late last year. Murphy is director of the Division of Marine Resources at the University of Washington and director of the Washington Sea Grant program. He is also a member of the Oceanographic Commission of Washington and president of the Oceanographic Institute of Washington . . . .

. . . . **Plans for library expansion and improvement** at the University of Miami's Rosenstiel School of Marine and Atmospheric Science have been advanced with the appointment of Alan Baldridge as associate professor and librarian, University sources report. Baldridge has been librarian at Stanford University's Hopkins Marine Station for 8½ years . . . .

. . . . **Claes G. Rooth, professor of physical oceanography** and atmospheric science, Rosenstiel School of Marine and Atmospheric Science, University of Miami, has been named chairman of the school's division of physical oceanography, the University reports. He succeeds Walter Duing who resigned to devote more time to research . . . .

. . . . A water pollution expert and authority on freshwater diatoms, **Ruth Patrick has won the $150,000 John and Alice Tyler Ecology Award** administered by Pepperdine University. Patrick, Chairman of the Board of the Academy of Sciences in Philadelphia, has authored a landmark report on water quality and most recently studied the impact of trace elements and heavy metals on algae growth . . . .

. . . . **Louis Berlinguet, University of Quebec,** has been named to the Fisheries Research Board of Canada (FRB), the Fisheries and Marine Service reports. His 5-year term began on January 1. The 18-member FRB, chaired by J. R. Weir, advises the Minister of State for Fisheries on fisheries and marine sciences research and development programs . . . .

. . . . **To reverse California's abalone decline** the Department of Fish and Game proposes reduced seasons and limits and a limited commercial entry system. Decline factors include habitat degradation, sea urchin competition, sea otter predation, improper size limits for some species, and heavy losses of sublegal abalones replaced by divers and shore pickers . . . .

. . . . **Irvin J. Strong has been appointed Executive Director, Fisheries Prices Support Board,** Fisheries and Marine Service, Department of the Environment, Canada, that agency reports. Strong will administer and implement the Board's programs by participating in the formulation of policies and programs and through monitoring and evaluating trends in the harvesting, production, pricing, and marketing of fishery products in Canada . . . .

. . . . The Environmental Protection Agency has issued a permit authorizing the Shell Chemical Company to **incinerate in the Gulf of Mexico two 4,200 metric ton shiploads of industrial chemical wastes**. The decision follows successful completion of two trial "burns," careful monitoring of which showed no measurable adverse effect on the environment, EPA officials noted . . . .

. . . . **Jack C. Parker, extension mariculture specialist** with the Texas Agricultural Extension Service and coordinator of Texas A&M University's Sea Grant-supported shrimp mariculture projects, has been named program manager for fisheries and mariculture research at that institution's Center for Marine Resources. Parker will also continue as project leader of mariculture work with the Agricultural Extension Service, according to University news sources . . . .

. . . . **Creation of the New York Sea Grant Institute,** by approval of the Boards of Trustees of both the State University of New York and Cornell University was reported late last year in *Coastlines*, the Institute's bimonthly newsletter. The Institute replaces the Sea Grant Program and officials report that it will expand its scope by bringing in, for the first time, other private and public colleges across the state. Faculty, students, personnel from state agencies, scientists from public and private sectors, business and industry leaders, and people from all levels of local government will also participate in the Institute's work. Financial resources will continue to be based on funds awarded by the National Sea Grant Program and state and local funds in the prescribed mixture defined by the National Sea Grant Act . . . .

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